DECLARATION

I, YOshihoto Shimizu, residing at Shimizu Patent Attorneys Office of 7F Idemitsu-Nagahori Bldg., 4-26, Minamisemba 3-chome, Chuoku, Osaka, JAPAN, do hereby certify that I am conversant with the English and Japanese languages and am a competent translator thereof. I further certify that to the best of my knowledge and belief the attached English translation is a true and correct translation made by me of U.S. Provisional Patent Application No. 60/447,745 filed February 19, 2003.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 7th day of February, 2005

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[Name of Document] Specification

[Title Of Invention] METHOD FOR MEASURING A SHAPE OF A TUBULAR MEMBER, APPARATUS FOR MEASURING THE SAME, METHOD FOR INSPECTING A TUBULAR MEMBER, APPARATUS FOR INSPECTING THE SAME, METHOD FOR MANUFACTURING A TUBULAR MEMBER, AND SYSTEM FOR MANUFACTURING THE SAME.

[Detail Explanation of the Invention]

[0001]

[Field of Invention]

The present invention relates to a method for measuring a shape of a tubular member, such as a substrate of a photosensitive drum for use in copying machines, an apparatus for measuring the same, a method for inspecting a tubular member, a system for inspecting the same, a method for manufacturing a tubular member, and a system for manufacturing the same.

[0002]

[Background Art]

In a tubular body to be used as a rotating member or the like in various machines, it is sometimes required to measure the precision of the shape. For example, in a substrate of a photosensitive drum for use in electrophotographic systems such as copying machines, a tubular body after the tube manufacturing steps is subjected to a shape measuring to keep high precision of the shape.

[0003]

As a method for measuring the shape, there is a method shown in Figs. 19 and 20. In this method, in a state in which the external

peripheral surface 12 of portions near both ends of the tubular body 10 are supported by rotating rollers 91, From the variation of the detected values of the displacement measuring devices 92 at the time of rotating the tubular body 90, the displacement at the longitudinal central portions of the external peripheral surface of the tubular body 90 in accordance with the rotation is measured.

[0004]

Various techniques for measuring a shape of a tubular body are disclosed by, for example, Japanese Unexamined Laid-open Publication Nos. H11-271008, S63-131018, 2001-3369920, H08-141643, H11-63955, H03-113114, 2000-292161 and H02-275305.

[0005]

[Patent Document 1] Japanese Unexamined Laid-open Publication Nos. H11-271008

[0006]

[Patent Document 2] Japanese Unexamined Laid-open Publication No. S63-131018

[0007]

[Patent Document 3] Japanese Unexamined Laid-open Publication No. 2001-3369920

[0008]

[Patent Document 4] Japanese Unexamined Laid-open Publication No. H08-141643

[0009]

[Patent Document 5] Japanese Unexamined Laid-open Publication No. H11-63955

[0010]

[Patent Document 6] Japanese Unexamined Laid-open Publication No. H03-113114

[0011]

[Patent Document 7] Japanese Unexamined Laid-open Publication No. 2000-292161

[0012]

[Patent Document 8] Japanese Unexamined Laid-open Publication No. H02-275305.

[0013]

[Problems to be solved by the invention]

However, in the method for measuring a shape of a tubular body as shown in Figs. 19 and 20 mentioned above and techniques disclosed in various Japanese Unexamined Laid-open Patent Publications, a tubular body which is an object to be measured is subjected to shape measuring as it is, and is not subjected to the shape measuring in a state in which the body is in actually use. Therefore, there are some cases in which a shape different from the shape in actual use is measured. Furthermore, there is a possibility that excessive quality is requested to keep the accuracy of the shape required at the time of the actual use.

[0014]

For example, in a case of a photosensitive drum, there is a case in which the cross-sectional shapes of both end portions are deformed into an appropriate true circular shape by being inserted by a flange which becomes a rotating axis at the actual use.

[0015]

In view of the above-identified problems, the present invention aims to provide a method for measuring a shape of a tubular member capable of measuring the shape with a high degree of accuracy, an apparatus for measuring the same, a method for inspecting such a tubular member, a system for inspecting the same, a method for manufacturing such a tubular member, and a system for manufacturing the same.

[0016]

[MEANS FOR SOLVING THE PROBLEMS]

The present invention provides the following means. That is:

(1) A method for measuring a shape of a tubular body, comprising:

temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing a plurality of correcting rollers into contact with the both end portions respectively;

rorating the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily corrected; and

detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body.

[0017]

(2) The method for measuring a shape of a tubular body as recited in the aforementioned Item 1, wherein three or more of the correcting rollers are brought into contact with the both end portions of the tubular body respectively.

[0018]

(3) The method for measuring a shape of a tubular body as recited in the aforementioned Item 2, wherein the correcting rollers include at least one inside correcting roller which comes into contact with an internal peripheral surface of the tubular body and at least one outside correcting roller which comes into contact with an outside peripheral surface of the tubular body.

[0019]

(4) The method for measuring a shape of a tubular body as recited in the aforementioned Item 3, wherein the inside correcting roller slidably moves in an axial direction of the tubular body so as to retract from the both end portion of the tubular body to an outside of the tubular body at the time of carrying the tubular body in and out a shape measuring position.

[0020]

(5) The method for measuring a shape of a tubular body as recited in the aforementioned Item 3 or 4, wherein the inside correcting roller and the outside correcting roller relatively move so as to depart from each other before and after the shape measuring of the tubular body.

[0021]

(6) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 3 to 5, wherein the inside correcting roller and the outside correcting roller come into contact with the internal peripheral surface of the tubular body and the external peripheral surface thereof at positions different along the circumferential direction of the tubular body.

[0022]

(7) The method for measuring a shape of a tubular body as recited in the aforementioned Item 6, wherein two or more outside correcting rollers are provided at the end portions of the tubular body respectively. Stable.

[0023]

(8) A method for measuring a shape of a tubular body, comprising:

temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing one or more inside correcting rollers into contact with internal peripheral surface of each of both end portions of the tubular body and bringing two or more inside correcting rollers into contact with exterior peripheral surface thereof;

rotating the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily being corrected; and

detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body.

[0024]

(9) The method for measuring a shape of a tubular body as recited in claim 7 or 8, wherein the two or more outside correcting rollers come into contact with a lower side of the tubular body at respective end portions of the tubular body.

[0025]

(10) The method for measuring a shape of a tubular body as recited in any one of claims 1 to 9, wherein, in a state in which

the cross-sectional shapes of both end portions of the tubular body are temporarily being corrected, the correcting rollers are fixed at respective positions.

[0026]

(11) A method for measuring a shape of a tubular body, comprising:

temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing one or more inside correcting rollers into contact with internal peripheral surface of each of both end portions of the tubular body and bringing three or more inside correcting rollers into contact with exterior peripheral surface thereof;

rotating the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily being corrected; and

detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body.

[0027]

(12) The method for measuring a shape of a tubular body as recited in the aforementioned Item 10 or 11, wherein the correcting rollers are fixed at respective positions where the correcting rollers just come into contact with corresponding assumed internal or external peripheral surface of the tubular body whose cross-sectional shape of both end portions is proper.

[0028]

(13) The method for measuring a shape of a tubular body as

recited in any one of the aforementioned Items 1 to 9, wherein pressing force is applied to the tubular body against at least one correcting roller.

[0029]

(14) The method for measuring a shape of a tubular body as recited in the aforementioned Item 13, wherein pressing force against the correcting roller changes in response to a rotational phase of the tubular body.

[0030]

(15) The method for measuring a shape of a tubular body as recited in the aforementioned Item 13 or 14, wherein the cross-sectional shape of the both end portions of the tubular body rotating with the cross-sectional shape being temporarily corrected is detected, and wherein the pressing force to be applied to the correcting roller is changed according to the cross-sectional shapes of the both end portions.

[0031]

(16) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 13 to 15, wherein at least one of the correcting rollers is fixed at a predetermined position in a state in which the cross-sectional shapes of the both end portions of the tubular body.

[0032]

(17) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 16, wherein the deformation of the both end portions of the tubular body due to the temporary correction is performed within an elastic

deformation region of the tubular body.

[0033]

(18) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 16, wherein the deformation of the both end portions of the tubular body due to the temporary correction is performed until the deformation reaches an elastic deformation region of the tubular body.

[0034]

(19) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 18, wherein at least one of the correcting rollers is rotatably driven.

[0035]

(20) The method for measuring a shape of a tubular body as recited in the aforementioned Item 19, wherein the rotatable driving of the correcting roller is performed by one rotating driving source.

[0036]

(21) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 20, wherein the detecting positions of the displacement includes a plurality of outside positions of the tubular body.

[0037]

(22) The method for measuring a shape of a tubular body as recited in the aforementioned Item 21, wherein the detecting positions of the displacement includes a plurality of positions of the tubular body different in axial position.

[0038]

(23) The method for measuring a shape of a tubular body as recited in the aforementioned Item 21 or 22, wherein the detecting positions of the displacement includes a plurality of positions of the tubular body same in axial position but different in circumferential position.

[0039]

(24) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 21 to 23, wherein the detecting positions of the displacement includes two positions of the tubular body same in axial position but different in circumferential position by a half circumferential length.

[0040]

(25) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 24, wherein the rotation of the tubular body is one or more.

[0041]

(26) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 25, wherein the detection of the displacement is continuously performed during the entire or a part of the rotating period of the tubular body.

[0042]

(27) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 25, wherein the detection of displacement is intermittently performed during the rotation of the tubular body.

[0043]

(28) The method for measuring a shape of a tubular body as

recited in any one of the aforementioned Items 1 to 25, wherein the rotation or the tubular body is intermittently stopped, and wherein the detection of displacement is performed when the rotation of the tubular body is stopped.

[0044]

(29) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 28, wherein the detection of displacement is performed using a detection device which comes into contact with the external peripheral surface of the tubular body.

[0045]

(30) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 28, wherein the detection of displacement is performed using a detection device which does not come into contact with the external peripheral surface of the tubular body.

[0046]

(31) The method for measuring a shape of a tubular body as recited in the aforementioned Item 30, wherein the detection of displacement is performed by irradiating a light from outside the tubular body and detecting the light transmitted through the tubular body.

[0047]

(32) The method for measuring a shape of a tubular body as recited in any one of the aforementioned Items 1 to 31, wherein the tubular body is a photosensitive substrate dram.

[0048]

(33) A method for inspecting a tubular body, comprising: measuring a shape of the tubular body in accordance with the method of measuring a tubular body as recited in any one of the aforementioned Items 1 to 32; and inspecting based on the measured result whether the shape of the tubular body falls within a predetermined allowable range.

[0049]

(34) A method for manufacturing a tubular body, comprising: inspecting the shape of the tubular body in accordance with the method of measuring a tubular body as recited in the aforementioned Item 33; and judging that the tubular body is a finished article when the shape of the tubular body falls within a predetermined allowable range according to the inspection result.

[0050]

(35) An apparatus for measuring a shape of a tubular body, comprising:

a plurality of correcting rollers which come into contact with both end portions of the tubular body to temporarily correct the cross-sectional shape thereof; and

at least one displacement detecting device which detects radial displacement of an external peripheral surface of the tubular body in accordance with a rotation of the tubular body when the tubular body is being rotated with the cross-sectional shape of the both end portions is temporarily being corrected.

[0051]

(36) An apparatus for inspecting a tubular body, comprising

a comparative means for inspecting whether the shape of the tubular body falls within a predetermined allowable range based on the displacement detected by the displacement detecting device.

[0052]

(37) A system for manufacturing a tubular body, comprising:

a tube manufacturing apparatus for manufacturing a tubular body;

an inspection apparatus for a tubular body as recited in the aforementioned Item 36;

an acceptance/rejection discriminating means for discriminating that the tubular body is a completed product if the inspection result by the inspection apparatus shows that the shape of the tubular body falls within the predetermined allowable range.

[0053]

The method for measuring a shape of a tubular body according to the present invention comprises temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing a plurality of correcting rollers into contact with the both end portions respectively, rorating the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily corrected, and detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body.

[0054]

With this method for measuring a shape of a tubular body, the radial displacement of the external peripheral surface of the tubular body is detected in a state in which the both end portions

are temporarily corrected with collecting rollers. Thus, the shape of the tubular body can be measured under the condition similar to the actual use of the tubular body in which the cross-sectional shapes of the both end portions are deformed into appropriate shapes. Accordingly, the shape of the tubular body in the actual use can be obtained with a high degree of accuracy, which in turn can prevent that excessive quality is requested so as to keep a required shape accuracy required at the actual use.

[0055]

In the tubular body shape measuring method, it is preferable that three or more correcting rollers are brought into contact with each end portion of the tubular body.

[0056]

In this case, the shape of the end portion of the tubular body can be corrected while holding the tubular body in a stable manner.

[0057]

Furthermore, in the tubular body shape measuring method, it is preferable that the correcting rollers include an inner correcting roller coming into contact with the internal peripheral surface of the tubular body 1 and an outer correcting roller coming into contact with the external peripheral surface of the tubular body.

[0058]

In this case, the tubular body can be stably supported by being pinched by and between from the inside and outside of the tubular body, and that correcting rollers can be disposed closely with each other. Thus, plural correcting rollers can be firmly positioned

to thereby enable accurate correcting of each end portion of the tubular body. Furthermore, it also becomes possible to perform a partial shape correction along the circumferential direction of the tubular body.

[0059]

In the tubular body shape measuring method, it is preferable that the inner correcting rollers can be slid in the axial direction of the tubular body to be positioned outside the tubular body from the end portion of the tubular body when the tubular body is carried in and out of the shape measuring position.

[0060]

In this case, by moving the inner correcting rollers in the axially outward direction at the time of setting the tubular body, the tubular body can be set to the shape measuring position without moving the tubular body in the axial direction thereof.

[0061]

Furthermore, in the tubular body shape measuring method, it is preferable that the inner correcting roller and the outer correcting roller are moved so as to be away from each other before and after measuring the shape of the tubular body.

[0062]

In this case, at the time of setting the tubular body, the tubular body is not pinched by and between the inner correcting roller and the outer correcting roller, enabling an easy setting of the tubular body into the shape measuring position.

[0063]

In the tubular body shape measuring method, it is preferable

that the inner correcting roller and the outer correcting roller come into contact with the internal peripheral surface and the external peripheral surface of the tubular body at different circumferential positions.

[0064]

In this case, correcting force can be effectively applied to the circumferential position of the tubular body pinched by and between the inner correcting roller and the outer correcting roller.

[0065]

In the tubular body shape measuring method, it is preferable that two or more outer correcting rollers are positioned at each end portion of the tubular body.

[0066]

In this case, since the tubular body can be supported by two or more outer correcting rollers, the posture of the tubular body can be stabilized.

[0067]

The method for measuring a shape of a tubular body according to the present invention comprises temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing one or more inside correcting rollers into contact with internal peripheral surface of each of both end portions of the tubular body and bringing two or more inside correcting rollers into contact with exterior peripheral surface thereof, rotating the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily being corrected, and detecting radial displacement of an external peripheral surface

of the tubular body caused by a rotation of the tubular body.

[0068]

With this method for measuring a shape of a tubular body, the radial displacement of the external peripheral surface can be detected with the both end portions temporarily corrected by the correcting rollers. Thus, the shape of the tubular body can be measured under the conditions similar to the actual use of the tubular body in a state in which the cross-sectional shape of each of the both end portions is deformed in an appropriate deformed shape. Therefore, the shape of the tubular body can be measured under the condition similar to the actual use of the tubular body in which the cross-sectional shapes of the both end portions are deformed into appropriate shapes. Accordingly, the shape of the tubular body in the actual use can be obtained with a high degree of accuracy, which in turn can prevent that excessive quality is requested so as to keep a required shape accuracy required at the actual use. Furthermore, it becomes possible to perform a partial shape correction in the peripheral direction of the tubular body by pinching from the inside and outside of the tubular body while stably holding the tubular body.

[0069]

In the tubular body shape measuring method, it is preferable that two or more outer correcting rollers come into contact with the lower side of the tubular body at both end portions of the tubular body.

[0070]

In this case, the outer correcting rollers below the tubular

body can be utilized as a provisional platform for temporarily supporting the tubular body before and after the setting of the tubular body to the shape measuring position.

[0071]

Furthermore, in the tubular body shape measuring method, it is preferable that the correcting rollers are fixed to predetermined positions respectively in the state in which the cross-sectional shape of the end portions of the tubular body are temporarily being corrected.

[0072]

In this case, the shape of each of the both end portion of the tubular body can be easily corrected into an appropriate shape without performing complex controls.

[0073]

A method for measuring a shape of a tubular body according to the present invention comprises temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing one or more inside correcting rollers into contact with internal peripheral surface of each of both end portions of the tubular body and bringing three or more inside correcting rollers into contact with exterior peripheral surface thereof, rotating the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily being corrected, and detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body.

[0074]

With this method for measuring a shape of a tubular body, the

radial displacement of the external peripheral surface can be detected with the both end portions temporarily corrected by the correcting rollers. Thus, the shape of the tubular body can be measured under the conditions similar to the actual use of the tubular body in a state in which the cross-sectional shape of each of the both end portions is deformed in an appropriate deformed shape. Therefore, the shape of the tubular body can be measured under the condition similar to the actual use of the tubular body in which the cross-sectional shapes of the both end portions are deformed into appropriate shapes. Accordingly, the shape of the tubular body in the actual use can be obtained with a high degree of accuracy, which in turn can prevent that excessive quality is requested so as to keep a required shape accuracy required at the actual use. Furthermore, it becomes possible to perform a partial shape correction in the peripheral direction of the tubular body by pinching from the inside and outside of the tubular body while stably holding the tubular body.

[0075]

Furthermore, in the tubular body shape measuring method, it is preferable that the correcting rollers are fixed to the positions where they just come into contact with the internal peripheral surface and the external peripheral surface of the tubular body, provided that the cross-sectional shape of each end portion of the tubular body is appropriate.

[0076]

In this case, the end portion of the tubular body can be corrected into an appropriate shape easily and assuredly without

performing complex controls or the like. Especially, the portions where the correcting rollers come into contact with and therearound can be more accurately corrected into an appropriate shape of the tubular body.

[0077]

Furthermore, in the tubular body shape measuring method, it is preferable that at least one of the correcting rollers applies pressing force against the tubular body.

[0078]

In this case, correcting flexibility can be obtained. Therefore, it becomes possible to perform an appropriate correcting depending concrete tubular body shape.

[0079]

Furthermore, in the tubular body shape measuring method, it is preferable that the pressing force applied to the correcting rollers is changed depending on the rotational phase of the tubular body.

[0080]

In this case, correcting force depending on the shape at each circumferential position of the tubular body can be applied, enabling more appropriate correcting operation.

[0081]

Furthermore, in the tubular body shape measuring method, it is preferable that, in a state in which the tubular body is being rotated with the cross-sectional shape of the end portion being temporarily corrected, the cross-sectional shape of the end portion is detected and pressing force applying to the correcting rollers

is changed depending on the cross-sectional shape of the end portion.

[0082]

In this case, since the cross-sectional shape of the end portion of the tubular body is detected, an appropriate correcting operation can be performed by applying correcting force depending on the cross-sectional shape of the tubule body based on the detected result.

[0083]

Furthermore, in the tubular body shape measuring method, it is preferable that at least one of the correcting rollers is fixed to a predetermined position in a state in which the cross-sectional shape of the end portion of the tubular body is being temporarily corrected.

[0084]

In this case, since the correcting roller fixed to the predetermined position can be used as a reference of the shape measurement of the tubular body, accurate shape measurement can be attained.

[0085]

Furthermore, in the tubular body shape measuring method, the deformation by the temporary correcting to the end portion of the tubular body can be performed within the elastic deforming region of the tubular body.

[0086]

In this case, the deformation of the tubular body during the shape measurement returns to the original shape, effects to the

tubular body by the shape measurement can be minimized assuredly.

[0087]

Furthermore, in the tubular body shape measuring method, the deformation by the temporary correction to the end portion of the tubular body can be made so as to reach the plastic deformation region.

[0088]

In this case, the cross-sectional shape of the end portion of the tubular body can be corrected assuredly into an appropriate shape regardless whether the deformation of the end portion of the tubular body has reached the plastic deformation region, enabling more accurate shape measurement.

[0089]

Furthermore, in the tubular body shape measuring method, it is preferable that at least one of the correcting rollers is rotatably driven.

[0090]

In this case, the correcting roller functions as a means for rotating the tubular body, minimizing the number of members which come into contact with the tubular body. This eliminates error factors to contribute to accurate shape measurement, resulting in high reliability in shape measurement, and also can decrease the possibility of damages to the tubular body.

[0091]

Furthermore, in the tubular body shape measuring method, it is preferable that the rotational driving of the correcting roller is performed by a single rotational driving source as recited in

claim 19.

[0092]

In this case, it becomes possible to restrain irregular rotation which may be generated when a plurality of rotational driving sources are employed and simplify the rotational control, resulting in high reliable shape measurement.

[0093]

Furthermore, it is preferable that the detecting positions for displacement include a plurality of positions outside the tubular body.

[0094]

In this case, the deflection of the external peripheral surface can be measured at plural positions at the outside of the tubular body. By combining the measured results, the shape of the tubular body can be recognized more concretely.

[0095]

Furthermore, in the tubular body shape measuring method, it is preferable that the detecting positions for displacement include a plurality of positions different in axial position of the tubular body.

[0096]

In this case, the deflection of the external peripheral surface can be measured at plural positions different in axial position of the tubular body. By combining the measured results, the change of the shape in the axial direction of the tubular body can be recognized.

[0097]

Furthermore, in the tubular body shape measuring method, it is preferable that the detecting positions for displacement include a plurality of positions same in axial position of the tubular body but different in circumferential position.

[0098]

In this case, by combining the measured displacement amounts detected at these plural positions, the cross-sectional shape at the axial position can be recognized more concretely.

[0099]

Furthermore, in the tubular body shape measuring method, it is preferable that the detecting positions for displacement include two positions same in axial position of the tubular body but different in circumferential position by a half circumferential length.

[0100]

In this case, by combining the measured displacement amounts detected at these two positions, the diameter passing these two positions can be obtained. Thus, the shape of the tubular element can be recognized more concretely.

[0101]

Furthermore, in the tubular body shape measuring method, it is preferable that the number of the rotation of the tubular body is one or more.

[0102]

In this case, the entire circumferential shape of the tubular body can be detected.

[0103]

Furthermore, in the tubular body shape measuring method, the detection of the displacement can be performed continuously during the entire period or a part of the period for rotating the tubular body.

[0104]

In this case, a partial shape change in the circumferential direction of the tubular body can also be detected.

[0105]

Furthermore, in the tubular body shape measuring method, the detection of the displacement can be performed intermittently during the period for rotating the tubular body.

[0106]

In this case, the displacement of the external peripheral surface of the tubular body can be easily detected.

[0107]

Furthermore, the rotation of the tubular body is intermittently stopped and the detection of the displacement can be performed when the rotation of the tubular body is stopped.

[0108]

In this case, the displacement of the external peripheral surface of the tubular body can be easily detected.

[0109]

Furthermore, the detection of the displacement can be performed by using a detecting device which comes into contact with the external peripheral surface of the tubular body.

[0110]

In this case, the displacement of the external peripheral

surface of the tubular body can be easily detected.

[0111]

Furthermore, in the tubular body shape measuring method, it is preferable that the detection of the displacement can be performed by using a detecting device which does not come into contact with the external peripheral surface of the tubular body.

[0112]

In this case, the displacement of the external peripheral surface of the tubular body can be detected without harming the external peripheral surface of the tubular body.

[0113]

Furthermore, in the tubular body shape measuring method, it is preferable that the detection of the displacement is performed by irradiating light against the tubular body from the outside thereof and detecting the light passed over the tubular body.

[0114]

In this case, the displacement of the external peripheral surface of the tubular body can be detected easily and accurately.

[0115]

Furthermore, as a tubular body to which the aforementioned tubular body shape measuring method can be applied, concretely, a photosensitive dram substrate can be exemplified.

[0116]

A method for inspecting a tubular body according to the present invention comprises measuring a shape of the tubular body in accordance with the method of measuring a tubular body as recited in any one of the aforementioned Items, and inspecting based on

the measured result whether the shape of the tubular body falls within a predetermined allowable range.

[0117]

With this tubular body inspection method, it is possible to discriminate whether the shape of the tubular body is within an allowable range.

[0118]

A method for manufacturing a tubular body according to the present invention, comprises inspecting the shape of the tubular body in accordance with the method of measuring a tubular body as recited in the aforementioned Item, and judging that the tubular body is a finished article when the shape of the tubular body falls within a predetermined allowable range according to the inspection result.

[0119]

With this tubular manufacturing method, it is possible to provide a tubular body having sufficient shape accuracy without causing excessive quality.

[0120]

Furthermore, an apparatus for measuring a shape of a tubular body according to the present invention comprises a plurality of correcting rollers which come into contact with both end portions of the tubular body to temporarily correct the cross-sectional shape thereof, and at least one displacement detecting device which detects radial displacement of an external peripheral surface of the tubular body in accordance with a rotation of the tubular body when the tubular body is being rotated with the cross-sectional

shape of the both end portions is temporarily being corrected.

[0121]

With this apparatus for measuring a shape of a tubular body, the radial displacement of the external peripheral surface can be detected with the both end portions temporarily corrected by the correcting rollers. Thus, the shape of the tubular body can be measured under the conditions similar to the actual use of the tubular body in a state in which the cross-sectional shape of each of the both end portions is deformed in an appropriate deformed shape. Therefore, the shape of the tubular body can be measured under the condition similar to the actual use of the tubular body in which the cross-sectional shapes of the both end portions are deformed into appropriate shapes. Accordingly, the shape of the tubular body in the actual use can be obtained with a high degree of accuracy, which in turn can prevent that excessive quality is requested so as to keep a required shape accuracy required at the actual use.

[0122]

Furthermore, an apparatus for inspecting a tubular body according to the present invention comprises a comparative means for inspecting whether the shape of the tubular body falls within a predetermined allowable range based on the displacement detected by the displacement detecting device.

[0123]

With this apparatus for inspecting a tubular body, it is possible to discriminate whether the shape of the tubular body is within an allowable range.

[0124]

A system for manufacturing a tubular body according to the present invention comprises a tube manufacturing apparatus for manufacturing a tubular body, an inspection apparatus for a tubular body as recited in the aforementioned Item, an acceptance/rejection discriminating means for discriminating that the tubular body is a completed product if the inspection result by the inspection apparatus shows that the shape of the tubular body falls within the predetermined allowable range.

[0125]

With this system for manufacturing a tubular body, it is possible to provide a tubular body having sufficient shape accuracy without causing excessive quality.

[0126]

[Embodiments of the Invention]

Hereinafter, with regard to a method and apparatus for measuring a shape of a tubular body, first, a principle of the measuring will be explained briefly.

[0127]

Fig. 1 is a schematic view to be used for explaining the method for measuring a shape of a tubular body according to the present invention. Fig. 2 is a side view thereof. Fig. 3 is a perspective view showing an example of a tubular body whose shape is to be measured.

[0128]

As shown in Figs. 1 and 2, in the method for measuring a shape of a tubular body according to the present invention, both end

portions 13 and 13 of the tubular body (work) 10 are corrected by inner correcting rollers 20 and 20 and outer correcting rollers 40, and the radial displacement of the external peripheral surface of the rotating tubular body 10 with the tubular body being corrected is detected with a displacement detecting device 30.

[0129]

<Tubular body>

The tubular body (work) 10 whose shape is to be measured according to the present invention has a circular cylindrical internal peripheral surface 11 and a circular cylindrical external peripheral surface 12.

[0130]

In this embodiment, as shown in Fig. 3, it is assumed that the tubular body (work) 10 exemplified in this embodiment is a member which will be used while being rotated in a state in which the opposite ends are supported by flanges 80 and 80 inserted therein.

[0131]

The flange 80 is formed into an accurate circular shape in cross-section. Such a flange 80 is inserted into the end portions 13 and 13 of the tubular body 10 and therefore the cross-sectional shape thereof will be corrected at the actual use.

[0132]

The positions where these flanges 80 and 80 are brought into contact with the tubular body 10 are, for example, the areas S (areas with hatching lines in Fig. 3) with a width d from both ends of the tubular body 10.

[0133]

Such tubular body 10 can be obtained by forming a long tubular body by extrusion of an aluminum, for example, and then cutting it into a predetermined length. However, as the material of such a tubular body (work) 10 to which the shape measuring method, etc. of the present invention is applied, aluminum alloy can be exemplified, but it is not limited to this and can be various metals or synthetic resins. The manufacturing method of the tubular body 10 is not limited to the aforementioned extrusion method, but can be any method capable of manufacturing a tubular body, such as drawing molding, casting, forging, injection molding, or a combination thereof.

[0134]

As such a tubular body 10, in concrete, a photosensitive drum substrate for use in copying machines or printers employing an electrophotography system can be exemplified.

[0135]

<Correcting roller>

At the time of performing the shape measurement, the inner correcting roller 20 and 20 and the outer correcting rollers 40 are brought into contact with the internal peripheral surface 11 of the end portion 13 of the tubular body 10 and the external peripheral surface 12 to temporarily correct the cross-sectional shape of the end portions 13 and 13 of the tubular body 10.

[0136]

The inner correcting roller 20 is disposed at each end of the tubular body 10, and therefore, a total of two inner correcting

rollers are disposed. Two outer correcting rollers 40 are disposed at each end of the tubular body 10, and therefore, a total of four inner correcting rollers are disposed.

[0137]

Two outer correcting rollers 40 and 40 disposed at each end portion of the tubular body 10 stabilize the position of the axis of the tubular body 10 and the posture of the tubular body 10, enabling the correction of the cross-sectional shape of each end portion of the tubular body 10 with a high degree of accuracy. Furthermore, this enables the tubular body 10 to be supported stably.

[0138]

Furthermore, the tubular body 10 is pinched by and between the inner correcting rollers 20 and the outer correcting rollers 40 from the inside thereof and the outside, enabling steady holding of the tubular body 10.

[0139]

Furthermore, since the inner correcting roller 20 and the outer correcting rollers 40 are disposed at the inside of the tubular body 10 and the outside, respectively, correcting force can be given to the tubular body 10 while closely disposing these rollers. In this embodiment, the inner correcting roller 20 and the outer correcting rollers 40 are disposed at the lower half region of the tubular body 10 falling within the angle of 90 degrees or less. Therefore, the inner correcting roller 20 and the outer correcting rollers 40 are positioned firmly, enabling each end portion of the tubular body 10 to be corrected accurately.

[0140]

The inner correcting roller 20 and the outer correcting rollers 40 are in contact with the inner peripheral surface 11 of the tubular body 10 and the outer peripheral surface 12, respectively, at different circumferential positions of the tubular body 10. Concretely, the inner correcting roller 20 is positioned between the outer correcting rollers 40. Since the inner correcting roller 20 and the outer correcting rollers 40 are disposed at different circumferential positions within a narrow region in the circumferential direction of the tubular body 10 as mentioned above, correcting force is given to the tubular body 10 effectively, enabling accurate shape correction.

[0141]

The portions of the tubular body 10 to which the inner correcting roller 20 and the outer correcting rollers 40 contact are portions of the internal peripheral surface 11 and the external peripheral surface 12 corresponding to the portions (hatched region S in Fig. 3) supported by the flange 80 when the tubular body 10 is actually used. Thus, the inner correcting roller 40 and the outer correcting rollers 40 are configured to correct the shape of the portion expected to be corrected by the flange 80 when the tubular body 10 is actually used.

[0142]

In the inner correcting roller 20 and the outer correcting roller 40, the external cylindrical peripheral surfaces thereof come into line-contact with the internal peripheral surface 11 of the tubular body 10 and the external peripheral surface 12,

respectively, causing the contact pressure by the inner correcting roller 20 and the outer correcting rollers 40 to be dispersed to thereby prevent local deformations of the tubular body 10.

[0143]

<Displacement detecting device>

The displacement detecting device 30 detects the radial displacement of the external peripheral surface 12 of the tubular body 12 when the tubular body 10 with the cross-sectional shape of the end portion 13 corrected by the inner and outer correcting rollers 20 and 40 is rotated. In this embodiment, it is assumed that a contact type displacement detecting device 30 detects the displacement by the operation of the contact member 31 which comes into contact with the external peripheral surface 12 of the tubular body 10. By using the displacement detecting device 30 which comes into contact with the external peripheral surface of the tubular body 10, it becomes possible to perform assured detection.

[0144]

The displacement detecting devices 30 are arranged at a plurality (three in this embodiment) positions as detecting positions different in axial direction of the tubular body 10. By combining the displacement amounts obtained at a plurality of portions different in axial position, the shape changes in the axial direction of the tubular body 10 can be grasped.

[0145]

(Examples of shape measurements)

Next, concrete tubular body shapes will be exemplified, and the following explanation will be directed to the case in which

the advantages of the method of measuring a shape of a tubular body.

[0146]

<Tubular body with flat ends>

As shown in Fig. 4, in the tubular body 101 according to the first example, the central portion 141 is formed into a perfect circular cross-sectional shape, but each end portion 131 is formed into a flat cross-sectional shape.

[0147]

The aforementioned shape tends to be generated at both end portions 131 and 131 of the tubular body 101 by cutting a long tubular body substrate formed by extrusion or the like as mentioned above into a certain length for manufacturing photosensitive drum substrates or the like for example.

[0148]

In the case of such a shape in which both end portions 131 and 131 are formed into a flat shape respectively, when the shape is measured in accordance with a conventional method as shown, for example, in Figs. 19 and 20, both end portions 131 and 131 to be supported will move up and down as the tubular body 101 rotates. This in turn causes the lower external peripheral surface of the longitudinal central portion of the tubular body 101 to be moved up and down. As a result, it is judged that the shape is far from the perfect cylindrical shape. In the case of a shape inspection with a certain acceptance level, there is a high possibility that it is judged as a defective item.

[0149]

In some cases, however, when flanges 80 and 80 are forcibly

inserted into both ends of the tubular body in the actual use as shown in Fig. 3, both end portions 131 and 131 of a tubular body 101 may be corrected into a perfect circular shape respectively, which resolves the shape defect. Thus, in such cases, it becomes a perfect cylindrical shape in the actual use, causing no problem. On the other hand, in another cases, even if flanges are forcibly inserted at the time of the actual use, a perfect cylindrical shape may not be obtained. Such a tubular body is a true defect item. In a conventional shape measuring method, such discrimination was impossible, and therefore there is a possibility that an item to be discriminated as a good item is discriminated as a defect item.

[0150]

To the contrary, in the shape measuring method according to this invention, the shape measurement of the tubular body 101 is performed while reproducing a shape of both end portions 131 and 131 of the tubular body 101 similar to that in the actual use by temporarily correcting them. Accordingly, even if the tubular body 101 has a false defect which will be dissolved at the time of actually being used at the vicinities of both end portions, it is possible to obtain a shape measuring result including a discrimination on whether the false defect is a permanent defect which will remain even in the actual use.

[0151]

As a result, an accurate shape measurement of a tubular body which had no choice but to be discriminated as a defect item in a conventional method can be performed, resulting in a perfect shape measuring result.

[0152]

<Tubular body flat in cross-section along entire length>

As shown in Fig. 5(a), the tubular body 102 as a second example is constant in cross-section along the entire length thereof, but the cross-sectional shape is not a perfect circular shape. Here, it is assumed that the cross-sectional shape is an elliptical shape formed by being pressed from the up-and-down direction or from the right-and-left direction.

[0153]

This shape tends to be generated at the time of manufacturing the tubular body 102 as a long tube by an extruding method or a drawing method.

[0154]

In the case of the shape deformed into a flat cross-section along the entire length of the tubular body 101, the conventional shape measuring method as shown in Figs. 19 and 20 tends to judge the shape to be a normal cylindrical tubular shape. That is, although the tubular body 102 to be rotated with its both end portions 132 and 132 supported moves up and down depending on the rotational phase, the lower external peripheral surface of the longitudinal central portion would hardly change in height position, causing the deflection to hardly be detected. Thus, In the case of a shape inspection with a certain acceptance level, there is a high possibility that it is judged to be a good item.

[0155]

In such a tubular body 102, even if both end portions thereof are corrected into a perfect circular shape respectively by forcibly

being inserted by flanges 80 and 80 at the time of the actual use, as shown in Fig. 5(b), the longitudinal central portion 103 of the tubular body 132 remains the flat cross-sectional shape. Thus, such a tubular body 102 may be a defective tube which causes large deflections at the time of the actual use.

[0156]

To the contrary, in the shape measuring method according to the present invention, the shape measurement of the tubular body 102 is performed while reproducing a shape of both end portions 132 and 132 of the tubular body 102 similar to that in the actual use by temporarily correcting them. Accordingly, even if the tubular body 102 has a shape defect difficult to be detected as shown in Figs. 5, it is possible to obtain a shape measuring result including discrimination on whether the defect is a permanent defect which will remain even in the actual use.

[0157]

As a result, an accurate shape measurement of a tubular body which had no choice but to be discriminated as a defect item in a conventional method can be performed, resulting in a perfect shape measuring result.

[0158]

(Concrete example)

Next, an embodiment is directed to an automatic type shape measuring apparatus in which the tubular body 10 (work) is automatically rotated by the driving force of the shape measuring device to perform the shape measuring.

[0159]

Fig. 6 is an entire schematic perspective view of this automatic type shape measuring apparatus. Fig. 7 is an enlarged perspective view showing the supporting structure of the tubular body in the apparatus. Fig. 8 is a front cross-sectional explanatory view showing the principle portion of the apparatus. Fig. 9 is a side cross-sectional view showing the principle portion of the apparatus.

[0160]

This shape measuring apparatus 5 is provided with outer correcting rollers for temporarily correcting the end portion 13 of the tubular body 10 by coming into contact with the external peripheral surface 12 of the tubular body 10, inner correcting rollers for temporarily correcting the end portion 13 of the tubular body 10 by coming into contact with the internal peripheral surface 11 of the tubular body 10, light transmittance type displacement detecting devices 53 disposed so as to locate the tubular body 10 therebetween in the direction perpendicular to the axial direction of the tubular body 10, and a main body base 50 on which the aforementioned parts are attached.

[0161]

<Outer correcting roller>

The outer correcting roller 54 temporarily corrects the end portion 13 of the tubular body 10 by coming into contact with the external peripheral surface of the tubular body 10.

[0162]

Furthermore, this outer correcting rollers 54 carry out the following functions: a function of rotatably driving the tubular

body 10; a function of positioning the axial position of the tubular body 10; a function of moving the tubular body 10 up and down; a function of stabilizing the height position of the tubular body 10 by supporting it from its lower side; and a function of temporarily supporting the tubular body 10 before correcting and measuring the shape.

[0163]

Two supporting rollers 54 are positioned below each end portion of the tubular body 10 at the same height, and the total of four supporting rollers 54 are provided to support both end portions of the tubular body 10. The two supporting rollers 54 and 54 positioned at one of the end portions of the tubular body 10 are configured to be a pair of rollers with parallel rotational axes as shown in Fig. 9, etc.

[0164]

Each supporting rollers 54 includes a small diameter portion 541 which comes into contact with the external peripheral surface 12 of the tubular body 10 to support the tubular body 10 from its lower side and a concentric larger diameter portion 542 formed at the outside of the small diameter portion 541.

[0165]

As shown in Fig. 8, the small diameter portion 541 of the supporting roller 54 is configured so as to come into contact with the tubular body 10 at a position which is near the end portion 13 of the tubular body 10. This prevents an occurrence of damage of the external peripheral surface 12 of the tubular body 10. Furthermore, the small diameter portion 541 comes into contact with

the portion near the end 13 of the tubular body 10, which makes it possible to correct the cross-sectional shape of the position to be corrected by flanges 80 at the time of the actual use of the tubular body 10.

[0166]

The larger diameter portion 542··· of the supporting roller 54··· comes into contact with the end face of the end portion 13 of the tubular body 10 to position the axial direction of the tubular body 10 to be set to the device 5. Thus, the distance between the supporting rollers 54···disposed at both ends of the tubular body 10 is set to correspond with the length of the tubular body 10. Since the positioning of the tubular body 10 in the axial direction is carried out by the supporting rollers 54···supporting the tubular body 10 as mentioned above, the number of members to be made contact with the tubular body 10 can be decreased. This eliminates the possible error factors as much as possible. In addition, this results in high reliability in shape measurement. Furthermore, the possible damage of the tubular body 10 can also be decreased.

[0167]

Each of the aforementioned supporting rollers 54··· is rotatably attached to the outer correcting roller support member 543 slidably attached to the device box 511 such that the slide movement direction thereof is restricted only to the up-and-down direction.

[0168]

At the lower side of the supporting rollers 54···, a coupling roller 544 which comes into contact with the external surface of

the larger diameter portion 542 of each supporting roller 54 is rotatably connected to the outer correcting roller support member 543. Since two outer correcting rollers 54 and 54 are driven by the coupling roller 544 at both sides of the tubular body 10, the rotational speed of these two supporting rollers 54 and 54 can be equalized. This in turn stabilizes the rotation of the tubular body 10, resulting in high reliability of the shape measurement.

[0169]

One of the pair of coupling rollers 544 and 544 is rotatably driven in a predetermined direction by the driving force of the driving motor 545 accommodated in the device box 511 to equally transmit the rotation of the coupling roller 544 to the two supporting rollers 54 and 54 which are in contact with the coupling roller 544, which in turn rotates the tubular body 10. Since the rotational driving force is transmitted to the tubular body 10 by the outer correcting rollers 54 and 54 supporting the tubular body 10, the number of members to be in contact with the tubular body 10 can be decreased. This contributes the accuracy of the shape measurement by eliminating error factors. Furthermore, since the rotation of the tubular body 10 is performed by a single rotation driving source, generation of rotational fluctuation which may occur when plural rotation driving sources are employed can be suppressed. The rotational control can also be simplified.

[0170]

The outer correcting roller support member 543 to which the outer correcting rollers 54 and 54 and the coupling roller 544 are attached is slidably driven in the up-and-down direction by a

lifting cylinder 546 attached to the device box 511.

[0171]

The outer correcting roller support member 543 comes into contact with the stopper 547 attached to the device box 511 at the upper limit side of the sliding operation of the lifting cylinder 546. This stopper 547 is positioned such that the relative positional relation of the outer correcting rollers 54 and the inner correcting roller 52 is positioned at the correcting position for correcting the cross-sectional shape of the end portion 13 of the tubular body 10 when the stopper 547 comes into contact with the outer correcting roller 52.

[0172]

The lifting cylinder 546 lifts the outer correcting roller supporting member 543 and the outer correcting rollers 54 together with the tubular body 10 and presses the outer correcting roller support member 543 against the stopper 547 with sufficiently large pressing force to thereby fix the position of the outer correcting roller 54 to the aforementioned correcting position. Since the position of the outer correcting roller 54 is fixed to the correcting position, no complicated control is not required at the time of performing the shape correction of both side end portion 13 of the tubular body 10.

[0173]

In this embodiment, the correcting positions of the outer correcting rollers 54 and the inner correcting roller 52 are positions where the outer correcting rollers 54 and the inner correcting roller 52 just come into contact with the external

peripheral surface and the internal peripheral surface of the both end portion 13 of the tubular body 10. That is, in cases where the cross-sectional shapes of the end portions 13 of the tubular body 10 are inappropriate, correcting force is applied to the tubular body 10 by the outer correcting rollers 54 and the inner correcting roller 52.

[0174]

<Inner correcting roller>

The inner correcting roller 52 temporarily corrects both end portions 13 by coming into contact with the inner peripheral surface of the tubular body 10.

[0175]

The inner correcting roller 52 is formed into a rotatable cylindrical member with bearings (not shown) so that the roller 52 can sift the contact position with the roller softly touching the interior peripheral surface 11 of the tubular body 10. Since the inner correcting roller 52 is formed as a cylindrical member, it can come into line-contact with the interior peripheral surface 11 of the tubular body 10, dispersing the pressing force, which in turn can prevent occurrence of damages on the interior peripheral surface 11 of the tubular body 10.

[0176]

This inner correcting roller 52 is supported by the pressure supporting axis 521 which is attached to the device boxes 511 and 511 upwardly stand on the main body base 50 in a penetrated manner so as to pinch the tubular body 10 in the axial direction thereof. Therefore, even when correcting force is applied to the both end

portions 13 and 13 of the tubular body 10, the positions (correcting positions) do not shift due to the reaction force. Furthermore, it has sufficient rigidity so as not to be impeded the smooth rotational force.

[0177]

Furthermore, this pressing support axis 521 is movable in the axial direction of the tubular body 10 by the driving portion 522 mounted in the device box 511. This causes an axial outward movement of the pair of inner correcting rollers 52 and 52 so as to be positioned outside the tubular body 10 when the tubular body 10 is set so that the tubular body 10 can be set in the shape measuring apparatus without making the tubular body 10 move in the axial direction.

[0178]

<Displacement detecting device>

The displacement detecting device 53 detects the radial displacement of the external peripheral surface 12 of the tubular body 10. In this embodiment, a total of five non-contact type detecting devices are provided at five positions different in axial position of the tubular body 10. The opposite two detecting devices among these five devices are disposed so as to detect the displacement of the cross-section of the position corresponding to the end portion 13 of the tubular body 10 whose cross-sectional shape is to be corrected by the inner correcting rollers 52 and the outer correcting roller 54.

[0179]

Each displacement detecting device 53 is a light

transmittance type displacement detecting device disposed so as to face the tubular body 10 from the direction perpendicular to the axial direction of the tubular body 10. Thus, a pair of a light irradiating portion and a light receiving portion disposed at both sides of the tubular body 10 constitutes each displacement detecting portion 53. The light (e.g., laser beam) irradiated from the light irradiating portion but not interrupted by the tubular body 10 will be detected by the light receiving portion to thereby detect the surface position of the external peripheral surface 12 of the tubular body 10.

[0180]

The detecting region 531 and 532 of each displacement detecting device 53 has a width exceeding the diameter of the tubular body 10 as shown in Fig. 8, etc. Each displacement detecting device 53 can simultaneously detect not only the displacement of one position of the external peripheral surface of the tubular body 10 but also the displacement of a position opposite to the aforementioned one position (a position moved from the position by a half peripheral length of the tubular body 10 in the circumferential direction thereof, a position rotated from the position by 180 degrees, or an opposite phase position). Thus, by combining the displacements detected at the opposite positions, the diameter of the tubular body 10 passing these two positions can be obtained, to thereby grasp the shape of the tubular body 10 more concretely.

[0181]

The aforementioned shape measuring apparatus 5 is provided

with a controller (not shown) for controlling the operation of each operating portion of the driving portion 522 for inwardly and outwardly moving the pair of inner correcting rollers 52 and 52, the driving motor 545 for driving the outer correcting rollers 54, the lifting driving cylinder 546 for lifting the outer correcting roller 54, the displacement detecting device 53 for measuring the shape of the tubular body 10, etc, so that the operation of each operating portion can be controlled at each timing of the shape measuring step.

[0182]

<Shape measuring steps>

The shape measuring steps can be exemplified as follows.

[0183]

The shape measuring operation using this shape measuring apparatus 5 is performed as follows. In a state in which each inner correcting roller 52 is moved outward by the operation of the driving portion 522, the tubular body 10 is carried by using any carrying device or manually to be disposed on the smaller diameter portions 541···of the outer correcting rollers 54···.

[0184]

Then, each inner correcting roller 52,52 is inserted into the tubular body 10 by the operation of the driving portion 522,522. In this state, the outer correcting rollers 54 and the tubular body 10 disposed thereon are raised by the lifting cylinders 546 and 546.

[0185]

When the relative position of the outer correcting rollers

54 with respect to the inner correcting roller 52 reach the correcting positions for correcting the cross-sectional shape of the end portion 13 of the tubular body 10, the outer correcting roller support member 543 comes into contact with the stopper 547 to be fixed. The height of the inner correcting rollers 52 are Fixed.

[0186]

At this time, the cross-sectional shape of each end portion and 13 of the tubular body 10 is temporarily corrected by being brought into contact with the outer and inner correcting rollers 54 and 52 fixed to the respective correcting position. The deformation of each end potion 13 of the tubular body 10 due to the temporarily correction includes an elastic deformation (can be en elastic deformation only), and the part thereof will be resumed to its original shape when the contact state of the inner and outer correcting rollers 52 and 54 is released.

[0187]

In the state in which the cross-sectional shape of each end portion 13 of the tubular body 10 is temporarily corrected, the tubular body 10 is rotated by rotating the coupling roller 544 and the outer correcting rollers 54 using the driving motor 545. The tubular body 10 keeps its contacting state with the outer correcting rollers 54 by its own weight.

[0188]

At this time, by each displacement detecting device 53, the radial displacement of the external peripheral surface 12 in the cross-sectional shape in the axial direction of the tubular body

10 is detected.

[0189]

When the displacement of the entire periphery along the peripheral direction is detected by rotating the tubular body 10 by one or more rotations, the carrying-out operation of this tubular body 10 can be performed by the procedures opposite to the aforementioned procedures, i.e., stopping the rotation of the tubular body 10, releasing the contact state of the inner and outer correcting rollers 52 and 544 to the tubular body 10 by moving the outer correcting rollers 54 and 54 downward, moving the inner correcting rollers 52 and 52 outward, and then taking out the measured tubular body 10.

[0190]

<Function and results>

In the shape measuring apparatus 5 constituted as mentioned above, in the state in which the cross-sectional shape of each end portion 13 of the tubular body 10 is temporarily corrected into an appropriate shape in the same manner as in the actual use, the displacement of the external peripheral surface can be measured. Therefore, the shape of the tubular body at the actual use can be measured with a high degree of accuracy.

[0191]

Furthermore, when the tubular body 10 is placed on the supporting rollers 54 and 54, the shape measurement can be performed automatically, enabling an easy employment into an automated line.

[0192]

Furthermore, the outer correcting rollers 54 for correcting

the tubular body 10 simultaneously functions the transmission of the rotational driving power to the tubular body 10, the positioning of the tubular body 10 in the axial direction, the lifting operation of the tubular body 10 and the support of the tubular body 10 from the lower side thereof. This realizes a structure having a smaller number of operation portions by combining the operation portions for setting of the tubular body to the shape measuring position and the shape measurement. Furthermore, the number of parts to be brought into contact with the tubular body 10 to be measured is small. This contributes to accurate shape measuring by eliminating error factors and also enables high reliability of shape measuring.

[0193]

Furthermore, the employment of the non-contact type displacement detecting devices 53 eliminates damages to the external peripheral surface of the tubular body 10.

[0194]

Furthermore, since this non-contact type displacement detecting device 53 is a light transmittance type displacement detecting device, the light is diffracted at the vicinity of the external peripheral surface 12 of the tubular body 10 which blocks the light to reach the light receiving portion, and therefore, appropriate detection results in which displacements of the external peripheral surface 12 due to unnecessary fine surface defects are deleted can be obtained.

[0195]

(Inspection apparatus)

Next, a tubular body inspecting apparatus according to the

present invention will be explained.

[0196]

Fig. 10 is a functional block diagram showing the structure of the inspecting apparatus 6.

[0197]

This inspecting apparatus 6 is equipped with an automatic shape measuring apparatus 5 mentioned above, a deflection amount calculating portion 61 for calculating the deflection amount of the external peripheral surface 12 from the displacement data of the external peripheral surface 12 detected by the shape measuring apparatus 5, an allowable range storing portion 62 for setting and storing the allowable range of the deflection of the external peripheral surface of the tubular body 10, a comparing portion 63 for discriminating whether the deflection amount of the tubular body 10 calculated by the deflection amount calculating portion 61, and an outputting portion 64 for outputting the inspected result.

[0198]

Concretely, the deflection amount calculating portion 61, the allowable range storing portion 62, the comparing portion 63 and the outputting portion 64 are comprised of software and hardware performing each function consisting of a computer.

[0199]

The deflection amounts treated in the deflection amount calculating portion 61, the allowable region storing portion 62 and the comparing portion 63 can be the deflection amounts at all five portions or some of them in the case where the displacements

of the external peripheral surface 12 at the five portions (five cross-sections) in the axial direction of the tubular body 10 are detected by the shape measuring apparatus 5 for example.

[0200]

Furthermore, even in the case where deflection amounts of plural portions (e.g., five portions) are used, the acceptable condition of the final inspection can be that each of all the deflection amounts fall within the predetermined allowable range or that the combination of the deflection amounts at plural portions falls within the predetermined allowable range. The example of the combination of the deflection amounts is that each of the deflection amount at the plural portions falls within the predetermined range and the total of these deflection amounts fall within the predetermined range.

[0201]

In this embodiment, the calculating means for processing the raw data of the displacement of the external peripheral surface of the tubular body 10 detected by the shape measuring apparatus 5 and calculating the index value or the like showing the shape of the tubular body 10 such as a deflection amount of the external peripheral surface is set outside the shape measuring apparatus 5. However, the shape measuring apparatus 5 can be provided with such a calculating means. Furthermore, the shape measuring apparatus 5 can have an outputting means for outputting the calculated result.

[0202]

(Manufacturing system)

Next, a tubular body manufacturing system according to the present invention will be explained.

[0203]

Fig. 11 is a functional block showing the structure of the manufacturing system 7.

[0204]

This manufacturing system 7 is provided with a tube manufacturing apparatus 71 for manufacturing a tubular body 10, the aforementioned inspecting apparatus 6 and a judging portion 72 for judging whether the tubular body 10 is a completed item based on the inspection result of the inspecting apparatus 6.

[0205]

The tube manufacturing apparatus 71 is an apparatus for manufacturing a tube by combining the extruding and drawing of a photosensitive drum substrate. Concretely, in the case of manufacturing an aluminum alloy photosensitive drum, the apparatus is constituted as an assembly of mechanical devices for carrying a step of manufacturing extruding material by dissolving raw materials, an extruding step, a drawing step, a correcting step, a cutting step for cutting into a predetermined length, a washing step, etc.

[0206]

The tubular body 10 manufactured as mentioned above is inspected whether the shape is in a predetermined allowable range. Based on the inspection result, the judging portion 72 judges the tubular body 10 as a completed item if it falls within the predetermined allowable range.

[0207]

It is preferable that the manufacturing system 7 is provided with an automatic carrying apparatus for automatically carrying the tubular body 10 from the tube manufacturing apparatus 71 to the shape measuring apparatus 5 of the inspecting apparatus 6.

[0208]

Furthermore, it is preferable that the manufacturing system 7 is provided with a carrying apparatus for carrying the completed item judged as an accepted product by the judging portion 72 and the possible defect product to different places.

[0209]

Furthermore, in the tubular body shape measuring apparatus 5 equipped in the inspecting apparatus 6, it is preferable to equip a feedback function for feeding the discrimination of the type or feature of the defect generated in the tubular body 10 back to the tube manufacturing apparatus 721 to prevent the generation of a defected product.

[0210]

(Another embodiment)

Although the above explanation was directed to a certain embodiment, the present invention is not limited to it and allows the following structure.

[0211]

(1) Although the correcting rollers are fixed to correcting positions at the time of measuring the shape while correcting the tubular body 10 in the above-mentioned embodiment, one or more correcting rollers can be pressed against the tubular body 10

without fixing the rollers. As a means for pressing the correcting roller against the tubular body 10, an air-pressure cylinder and a servomotor can be exemplified.

[0212]

Even in cases where the correcting roller is pressed against the tubular body 10, it is preferable that the position of at least one correcting roller is fixed because the position of the fixed correcting roller can be used as a reference of shape measurement.

[0213]

In cases where correcting rollers are pressed against the tubular body 10, it is preferable that the pressing force of the correcting roller against the tubular body 10 is changed. Concretely, for example, larger pressing force (correcting force) can be given to a portion having a cross-sectional shape away from an appropriate perfect circular shape, while smaller pressing force or no pressing force can be given to a portion having a cross-sectional shape similar to a perfect circular shape.

[0214]

Alternatively, the cross-sectional shape of each end portion 13,13 of the tubular body 10 can be actually detected, and the pressing force (correcting force) against the tubular body 10 can be changed depending on the detected concrete cross-sectional shape. This assuredly enables an appropriate correction of each end portion 13 of the tubular body 10.

[0215]

The detection of the cross-sectional shape of each end portion 13 of this tubular body 10 can be performed before or during the

correction. Detecting the cross-sectional shape while correcting each end portion 13 of the tubular body 10 enables an operator to know whether the pressing force (correcting force) is appropriate to the correction of the cross-sectional shape.

[0216]

As a means for detecting the cross-sectional shape of each end portion of the tubular body 10, a displacement detecting device for detecting the radial displacement of the external peripheral surface of the tubular body 10 can be used.

[0217]

In this case, as shown in Fig. 12, it is preferable to employ an outer correcting roller 55 with a small diameter portion 552 forming a groove 553 at the widthwise central portion of the external peripheral surface 551 and pass a laser beam from an optical transmission type displacement detecting device through the gap. This enables a detection of the cross-sectional shape being corrected by and between the inner correcting roller 52 and the outer correcting rollers 55.

[0218]

(2) In the aforementioned embodiment, although one inner correcting roller and two outer correcting rollers are disposed at each end of the tubular body 10, positioning of these correcting rollers is not limited to the above, and can be various positions as exemplified below.

[0219]

(2-1) As shown in Fig. 13, in addition to the one inner correcting roller 911 and the two outer correcting rollers 912 and

913 positioned below the tubular body 10 employed in the aforementioned embodiment, an additional outer correcting roller 914 positioned above the tubular body 10 can be employed. In this case, the tubular body 10 is pinched by and between the outer correcting rollers 912, 913 and 914, effectively correcting the elliptical cross-sectional shape of the tubular body.

[0220]

(2-2) As shown in Fig. 14, all of the correcting rollers can be inner correcting rollers 920···. As shown in Fig. 15, all of the correcting rollers can be outer correcting rollers 930···.

[0221]

(2-3) As shown in Fig. 16, an inner correcting roller 941 and an outer correcting roller 942 can be placed at the same circumferential position of the tubular body 10 to restrain the tubular body 10 by pinching the tubular body 10 from its inside and outside, and the correction can be performed by another correcting roller 943 disposed at a circumferentially different position.

[0222]

(2-4) As shown in Fig. 17, it can be configured such that a plurality of pairs (two pairs in Fig.17) each insisting of an inner correcting roller 951 and an outer correcting roller 952 are disposed at different circumferential positions of the tubular body 10 to restrain the tubular body 10 by pinching the plural circumferential positions thereof. In this case, it is possible to correct any portion of the tubular body having a radius of curvature larger or smaller than an appropriate radius of curvature.

[0223]

(2-5) As shown in Fig. 18, it can be configured such that a number of correcting rollers 96··· (eight in Fig.18) are disposed so as to come into contact with the external or internal peripheral surface of the tubular body 10 to correct the shape. Disposing four or more correcting rollers inside or outside the tubular body 10 enables an appropriate correction with respect to a triangular shape.

[0224]

(3) The correction can be performed such that the degree of deformation caused by the correction of the end portion 13,13 of the tubular body 10 falls within the elastic deformation range. In this case, reliability that the shape of the tubular body does not change by the shape measurement can be obtained.

[0225]

(4) In the aforementioned embodiment, the correcting rollers are brought into contact with the position to be supported at the time of using the tubular body. However, the correcting rollers can be positioned at any end portion of the tubular body near the position to be supported.

[0226]

(5) In the ninth embodiment, although the shape measurement is performed with the axial direction of the tubular body 10 disposed approximately horizontally, the shape measurement can be performed with the axial direction disposed approximately horizontally. In this case, the deformation of the tubular body 10 due to its own weight can be decreased.

[0227]

(6) In the aforementioned embodiment, although a plurality of detecting positions for the displacement are provided, the detecting position can be at least one.

[0228]

(7) In the aforementioned embodiment, although a photosensitive drum substrate is exemplified as a tubular body to be measured, the tubular body is not limited to this. Conveyance rollers, developing rollers or transferring rollers for use in copying machines or the like can also be applied. In addition to the above, any tubular bodies can be measuring objects of the present invention.

[0229]

(8) In the aforementioned embodiment, although a light transmittance type displacement detecting device (light transmittance type optical sensor) which does not come into contact with the tubular body 10 is exemplified as a displacement detecting device, the displacement detecting device is not limited to the above so long as it is possible to detect the radial displacement of the external peripheral surface 12 of the tubular body 10. As a displacement detecting device, it is possible to employ any detecting device based on various measuring principles, such as a contact type displacement sensor which comes into contact with the external peripheral surface of the tubular body 10 to detect the displacement, a reflection optical sensor capable of detecting the displacement in a non-contact state, an all-purpose image processing CCD camera or line camera capable of detecting the

displacement in a non-contact state and applicable to any material, a current-type displacement sensor capable of detecting the displacement in a non-contact state and high in accuracy, high in processing speed, strong in environment and cheap in cost, a capacitance-type displacement sensor capable of detecting the displacement in a non-contact state and high in accuracy, an air-type (differential pressure type) displacement sensor capable of detecting the displacement in a non-contact state, or an ultrasonic type displacement sensor capable of performing a long distance measurement.

[0230]

(9) In the aforementioned embodiment, the tubular body 10 is rotated by rotatably driving the outer correcting roller 54. However, the tubular body 10 can be rotated by an operator's hand, or by directly contacting a driving roller (not shown) or the like, or by any other method.

[0231]

(10) In the aforementioned embodiment, the displacement of the external peripheral surface of the tubular body 10 is detected while rotating the tubular body 10. However, the detection of the displacement of the external peripheral surface can be performed by intermittently stopping the rotation of the tubular body 10.

[0232]

(11) In the aforementioned embodiment, the outer correcting rollers 54 are lifted with the height of the inner correcting roller 52,52 fixed. However, the inner correcting roller 52,52 can be moved downward.

[0233]

[Effects of the invention]

As mentioned above, the method for measuring a shape of a tubular body according to the present invention comprises temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing a plurality of correcting rollers into contact with the both end portions respectively, rorating the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily corrected, and detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body. Therefore, the radial displacement of the external peripheral surface of the tubular body is detected in a state in which the both end portions are temporarily corrected with collecting rollers. Thus, the shape of the tubular body can be measured under the condition similar to the actual use of the tubular body in which the cross-sectional shapes of the both end portions are deformed into appropriate shapes. Accordingly, the shape of the tubular body in the actual use can be obtained with a high degree of accuracy, which in turn can prevent that excessive quality is requested so as to keep a required shape accuracy required at the actual use.

[0234]

In the tubular body shape measuring method, if three or more correcting rollers are brought into contact with each end portion of the tubular body, the shape of the end portion of the tubular body can be corrected while holding the tubular body in a stable manner.

[0235]

Furthermore, in the tubular body shape measuring method, in cases where the correcting rollers include an inner correcting roller coming into contact with the internal peripheral surface of the tubular body 1 and an outer correcting roller coming into contact with the external peripheral surface of the tubular body, the tubular body can be stably supported by being pinched by and between from the inside and outside of the tubular body, and that correcting rollers can be disposed closely with each other. Thus, plural correcting rollers can be firmly positioned to thereby enable accurate correcting of each end portion of the tubular body. Furthermore, it also becomes possible to perform a partial shape correction along the circumferential direction of the tubular body.

[0236]

In the tubular body shape measuring method, in cases where the inner correcting rollers can be slid in the axial direction of the tubular body to be positioned outside the tubular body from the end portion of the tubular body when the tubular body is carried in and out of the shape measuring position, by moving the inner correcting rollers in the axially outward direction at the time of setting the tubular body, the tubular body can be set to the shape measuring position without moving the tubular body in the axial direction thereof.

[0237]

Furthermore, in the tubular body shape measuring method, in cases where the inner correcting roller and the outer correcting roller are moved so as to be away from each other before and after

measuring the shape of the tubular body, at the time of setting the tubular body, the tubular body is not pinched by and between the inner correcting roller and the outer correcting roller, enabling an easy setting of the tubular body into the shape measuring position.

[0238]

In the tubular body shape measuring method, in cases where the inner correcting roller and the outer correcting roller come into contact with the internal peripheral surface and the external peripheral surface of the tubular body at different circumferential positions, correcting force can be effectively applied to the circumferential position of the tubular body pinched by and between the inner correcting roller and the outer correcting roller.

[0239]

In the tubular body shape measuring method, in cases where two or more outer correcting rollers are positioned at each end portion of the tubular body, since the tubular body can be supported by two or more outer correcting rollers, the posture of the tubular body can be stabilized.

[0240]

The method for measuring a shape of a tubular body according to the present invention comprises temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing one or more inside correcting rollers into contact with internal peripheral surface of each of both end portions of the tubular body and bringing two or more inside correcting rollers into contact with exterior peripheral surface thereof, rotating

the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily being corrected, and detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body. Therefore, the radial displacement of the external peripheral surface can be detected with the both end portions temporarily corrected by the correcting rollers. Thus, the shape of the tubular body can be measured under the conditions similar to the actual use of the tubular body in a state in which the cross-sectional shape of each of the both end portions is deformed in an appropriate deformed shape. Therefore, the shape of the tubular body can be measured under the condition similar to the actual use of the tubular body in which the cross-sectional shapes of the both end portions are deformed into appropriate shapes. Accordingly, the shape of the tubular body in the actual use can be obtained with a high degree of accuracy, which in turn can prevent that excessive quality is requested so as to keep a required shape accuracy required at the actual use. Furthermore, it becomes possible to perform a partial shape correction in the peripheral direction of the tubular body by pinching from the inside and outside of the tubular body while stably holding the tubular body.

[0241]

In the tubular body shape measuring method, in cases where two or more outer correcting rollers come into contact with the lower side of the tubular body at both end portions of the tubular body, the outer correcting rollers below the tubular body can be utilized as a provisional platform for temporarily supporting the

tubular body before and after the setting of the tubular body to the shape measuring position.

[0242]

Furthermore, in the tubular body shape measuring method, in cases where the correcting rollers are fixed to predetermined positions respectively in the state in which the cross-sectional shape of the end portions of the tubular body are temporarily being corrected, the shape of each of the both end portion of the tubular body can be easily corrected into an appropriate shape without performing complex controls.

[0243]

Furthermore, a method for measuring a shape of a tubular body according to the present invention comprises temporarily correcting cross-sectional shapes of both end portions of the tubular body by bringing one or more inside correcting rollers into contact with internal peripheral surface of each of both end portions of the tubular body and bringing three or more inside correcting rollers into contact with exterior peripheral surface thereof, rotating the tubular body in a state in which the cross-sectional shapes of the both end portions are temporarily being corrected, and detecting radial displacement of an external peripheral surface of the tubular body caused by a rotation of the tubular body. Therefore, the radial displacement of the external peripheral surface can be detected with the both end portions temporarily corrected by the correcting rollers. Thus, the shape of the tubular body can be measured under the conditions similar to the actual use of the tubular body in a state in which the cross-sectional

shape of each of the both end portions is deformed in an appropriate deformed shape. Therefore, the shape of the tubular body can be measured under the condition similar to the actual use of the tubular body in which the cross-sectional shapes of the both end portions are deformed into appropriate shapes. Accordingly, the shape of the tubular body in the actual use can be obtained with a high degree of accuracy, which in turn can prevent that excessive quality is requested so as to keep a required shape accuracy required at the actual use. Furthermore, it becomes possible to perform a partial shape correction in the peripheral direction of the tubular body by pinching from the inside and outside of the tubular body while stably holding the tubular body.

[0244]

Furthermore, in the tubular body shape measuring method, in cases where the correcting rollers are fixed to the positions where they just come into contact with the internal peripheral surface and the external peripheral surface of the tubular body, provided that the cross-sectional shape of each end portion of the tubular body is appropriate, the end portion of the tubular body can be corrected into an appropriate shape easily and assuredly without performing complex controls or the like. Especially, the portions where the correcting rollers come into contact with and therearound can be more accurately corrected into an appropriate shape of the tubular body.

[0245]

Furthermore, in the tubular body shape measuring method, in cases where at least one of the correcting rollers applies pressing

force against the tubular body, correcting flexibility can be obtained. Therefore, it becomes possible to perform an appropriate correcting depending concrete tubular body shape.

[0246]

Furthermore, in the tubular body shape measuring method, in cases where the pressing force applied to the correcting rollers is changed depending on the rotational phase of the tubular body, correcting force depending on the shape at each circumferential position of the tubular body can be applied, enabling more appropriate correcting operation.

[0247]

Furthermore, in the tubular body shape measuring method, in cases where, in a state in which the tubular body is being rotated with the cross-sectional shape of the end portion being temporarily corrected, the cross-sectional shape of the end portion is detected and pressing force applying to the correcting rollers is changed depending on the cross-sectional shape of the end portion, since the cross-sectional shape of the end portion of the tubular body is detected, an appropriate correcting operation can be performed by applying correcting force depending on the cross-sectional shape of the tubule body based on the detected result.

[0248]

Furthermore, in the tubular body shape measuring method, in cases where at least one of the correcting rollers is fixed to a predetermined position in a state in which the cross-sectional shape of the end portion of the tubular body is being temporarily corrected, since the correcting roller fixed to the predetermined position

can be used as a reference of the shape measurement of the tubular body, accurate shape measurement can be attained.

[0249]

Furthermore, in the tubular body shape measuring method, in cases where the deformation by the temporary correcting to the end portion of the tubular body is performed within the elastic deforming region of the tubular body, the deformation of the tubular body during the shape measurement returns to the original shape, effects to the tubular body by the shape measurement can be minimized assuredly.

[0250]

Furthermore, in the tubular body shape measuring method, in cases where the deformation by the temporary correction to the end portion of the tubular body is made so as to reach the plastic deformation region, the cross-sectional shape of the end portion of the tubular body can be corrected assuredly into an appropriate shape regardless whether the deformation of the end portion of the tubular body has reached the plastic deformation region, enabling more accurate shape measurement.

[0251]

Furthermore, in the tubular body shape measuring method, in cases where at least one of the correcting rollers is rotatably driven, the correcting roller functions as a means for rotating the tubular body, minimizing the number of members which come into contact with the tubular body. This eliminates error factors to contribute to accurate shape measurement, resulting in high reliability in shape measurement, and also can decrease the

possibility of damages to the tubular body.

[0252]

Furthermore, in the tubular body shape measuring method, in cases where the rotational driving of the correcting roller is performed by a single rotational driving source, it becomes possible to restrain irregular rotation which may be generated when a plurality of rotational driving sources are employed and simplify the rotational control, resulting in high reliable shape measurement.

[0253]

Furthermore, in cases where the detecting positions for displacement include a plurality of positions outside the tubular body, the deflection of the external peripheral surface can be measured at plural positions at the outside of the tubular body. By combining the measured results, the shape of the tubular body can be recognized more concretely.

[0254]

Furthermore, in the tubular body shape measuring method, in cases where the detecting positions for displacement include a plurality of positions different in axial position of the tubular body, the deflection of the external peripheral surface can be measured at plural positions different in axial position of the tubular body. By combining the measured results, the change of the shape in the axial direction of the tubular body can be recognized.

[0255]

Furthermore, in the tubular body shape measuring method, in cases where the detecting positions for displacement include a

plurality of positions same in axial position of the tubular body but different in circumferential position, by combining the measured displacement amounts detected at these plural positions, the cross-sectional shape at the axial position can be recognized more concretely.

[0256]

Furthermore, in the tubular body shape measuring method, in cases where the detecting positions for displacement include two positions same in axial position of the tubular body but different in circumferential position by a half circumferential length, by combining the measured displacement amounts detected at these two positions, the diameter passing these two positions can be obtained. Thus, the shape of the tubular element can be recognized more concretely.

[0257]

Furthermore, in the tubular body shape measuring method, in cases where the number of the rotation of the tubular body is one or more, the entire circumferential shape of the tubular body can be detected.

[0258]

Furthermore, in the tubular body shape measuring method, in cases where the detection of the displacement can be performed continuously during the entire period or a part of the period for rotating the tubular body, a partial shape change in the circumferential direction of the tubular body can also be detected.

[0259]

Furthermore, in the tubular body shape measuring method, in

cases where the detection of the displacement can be performed intermittently during the period for rotating the tubular body, the displacement of the external peripheral surface of the tubular body can be easily detected.

[0260]

Furthermore, in cases where the rotation of the tubular body is intermittently stopped and the detection of the displacement can be performed when the rotation of the tubular body is stopped, the displacement of the external peripheral surface of the tubular body can be easily detected.

[0261]

Furthermore, in cases where the detection of the displacement is performed by using a detecting device which comes into contact with the external peripheral surface of the tubular body, the displacement of the external peripheral surface of the tubular body can be easily detected.

[0262]

Furthermore, in the tubular body shape measuring method, in cases where the detection of the displacement is performed by using a detecting device which does not come into contact with the external peripheral surface of the tubular body, the displacement of the external peripheral surface of the tubular body can be detected without harming the external peripheral surface of the tubular body.

[0263]

Furthermore, in the tubular body shape measuring method, in cases where the detection of the displacement is performed by irradiating light against the tubular body from the outside thereof

and detecting the light passed over the tubular body, the displacement of the external peripheral surface of the tubular body can be detected easily and accurately.

[0264]

Furthermore, a method for inspecting a tubular body according to the present invention comprises measuring a shape of the tubular body in accordance with the method of measuring a tubular body as recited in any one of the aforementioned Items, and inspecting based on the measured result whether the shape of the tubular body falls within a predetermined allowable range. Therefore, it is possible to discriminate whether the shape of the tubular body is within an allowable range.

[0265]

A method for manufacturing a tubular body according to the present invention, comprises inspecting the shape of the tubular body in accordance with the method of measuring a tubular body as recited in the aforementioned Item, and judging that the tubular body is a finished article when the shape of the tubular body falls within a predetermined allowable range according to the inspection result. Therefore, it is possible to provide a tubular body having sufficient shape accuracy without causing excessive quality.

[0266]

Furthermore, an apparatus for measuring a shape of a tubular body according to the present invention comprises a plurality of correcting rollers which come into contact with both end portions of the tubular body to temporarily correct the cross-sectional shape thereof, and at least one displacement detecting device which

detects radial displacement of an external peripheral surface of the tubular body in accordance with a rotation of the tubular body when the tubular body is being rotated with the cross-sectional shape of the both end portions is temporarily being corrected. Therefore, the radial displacement of the external peripheral surface can be detected with the both end portions temporarily corrected by the correcting rollers. Thus, the shape of the tubular body can be measured under the conditions similar to the actual use of the tubular body in a state in which the cross-sectional shape of each of the both end portions is deformed in an appropriate deformed shape. Therefore, the shape of the tubular body can be measured under the condition similar to the actual use of the tubular body in which the cross-sectional shapes of the both end portions are deformed into appropriate shapes. Accordingly, the shape of the tubular body in the actual use can be obtained with a high degree of accuracy, which in turn can prevent that excessive quality is requested so as to keep a required shape accuracy required at the actual use.

[0267]

Furthermore, an apparatus for inspecting a tubular body according to the present invention comprises a comparative means for inspecting whether the shape of the tubular body falls within a predetermined allowable range based on the displacement detected by the displacement detecting device. Therefore, it is possible to discriminate whether the shape of the tubular body is within an allowable range.

[0268]

A system for manufacturing a tubular body according to the present invention comprises a tube manufacturing apparatus for manufacturing a tubular body, an inspection apparatus for a tubular body as recited in the aforementioned Item, an acceptance/rejection discriminating means for discriminating that the tubular body is a completed product if the inspection result by the inspection apparatus shows that the shape of the tubular body falls within the predetermined allowable range. Therefore, it is possible to provide a tubular body having sufficient shape accuracy without causing excessive quality.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

Fig. 1 is a schematic view for explaining the method for measuring a shape of a tubular body according to the present invention.

[Fig. 2]

Fig. 2 is a side cross-sectional view thereof.

[Fig. 3]

Fig. 3 is a perspective view showing an example of the tubular body to be measured.

[Fig. 4]

Fig. 4 is an explanatory view showing the tubular body in which the opposite end portions are deformed into a flattened shape.

[Fig. 5]

Fig. 5(a) is an explanatory view of the flattened tubular body flat in cross-section along the entire length, and Fig. 5(b) is an explanatory view showing the use status of the flattened tubular

body.

[Fig. 6]

Fig. 6 is an entire perspective schematic view showing an example of an apparatus for measuring a shape of a tubular body according to the present invention.

[Fig. 7]

Fig. 7 is an enlarged perspective view showing the supporting structure of the tubular body of the apparatus.

[Fig. 8]

Fig. 8 is a front cross-sectional explanatory view of the principal portion of the apparatus.

[Fig. 9]

Fig. 9 is a side cross-sectional view of the principal portion of the apparatus.

[Fig. 10]

Fig. 10 is a functional block diagram showing the structure of the inspection apparatus according to the present invention.

[Fig. 11]

Fig. 11 is a functional block diagram showing the structure of the manufacturing system of a tubular body according to the present invention.

[Fig. 12]

Fig. 12 is an explanatory view in the case where an outer correcting roller with a dented portion is applied.

[Fig. 13]

Fig. 13 is a first modified example in which the position of the correcting roller is different.

[Fig. 13]

Fig. 13 is a first modified example in which the position of the correcting roller is different.

[Fig. 14]

Fig. 14 is a second modified example in which the position of the correcting roller is different.

[Fig. 15]

Fig. 15 is a third modified example in which the position of the correcting roller is different.

[Fig. 16]

Fig. 16 is a fourth modified example in which the position of the correcting roller is different.

[Fig. 17]

Fig. 17 is a fifth modified example in which the position of the correcting roller is different.

[Fig. 18]

Fig. 18 is a sixth modified example in which the position of the correcting roller is different.

[Fig. 20]

Fig. 20 is an explanatory view showing the principal of a conventional shape measuring method of a tubular body.

[Description of the reference numeral]

10 tubular body (work)

11 interior peripheral surface

12 exterior peripheral surface

13 end surface

20, 52 inner correcting roller

30, 53 displacement detecting device

40, 54 outer correcting roller

5 apparatus for measuring a shape of a tubular body

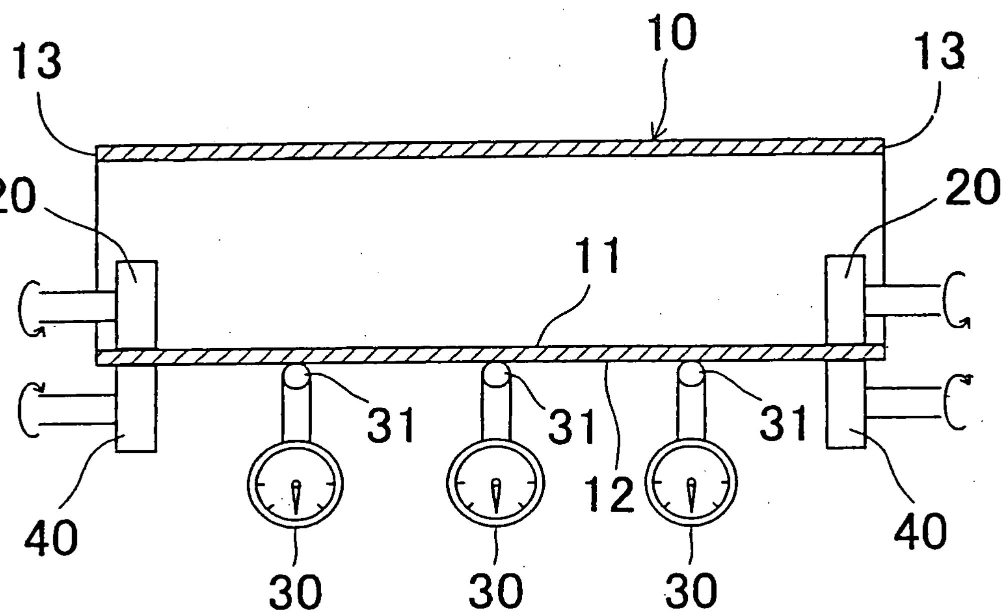
6 inspection apparatus

7 manufacturing system

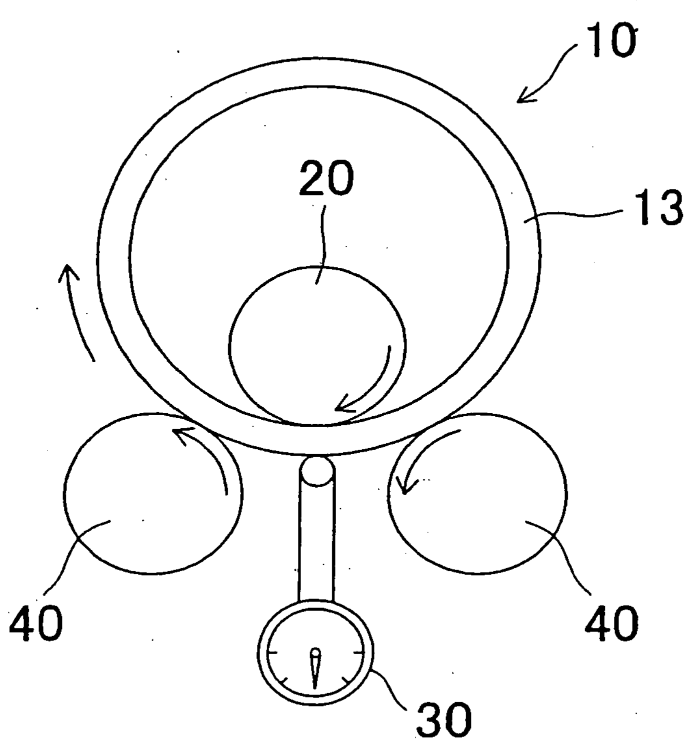
[Name of Document] Drawings

【書類名】 図面

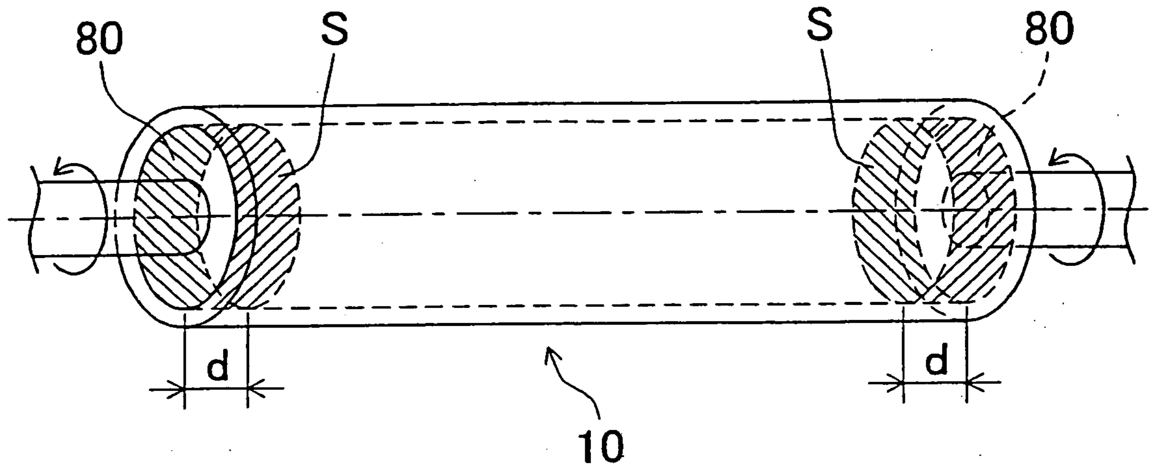
【図1】 [Fig. 1]



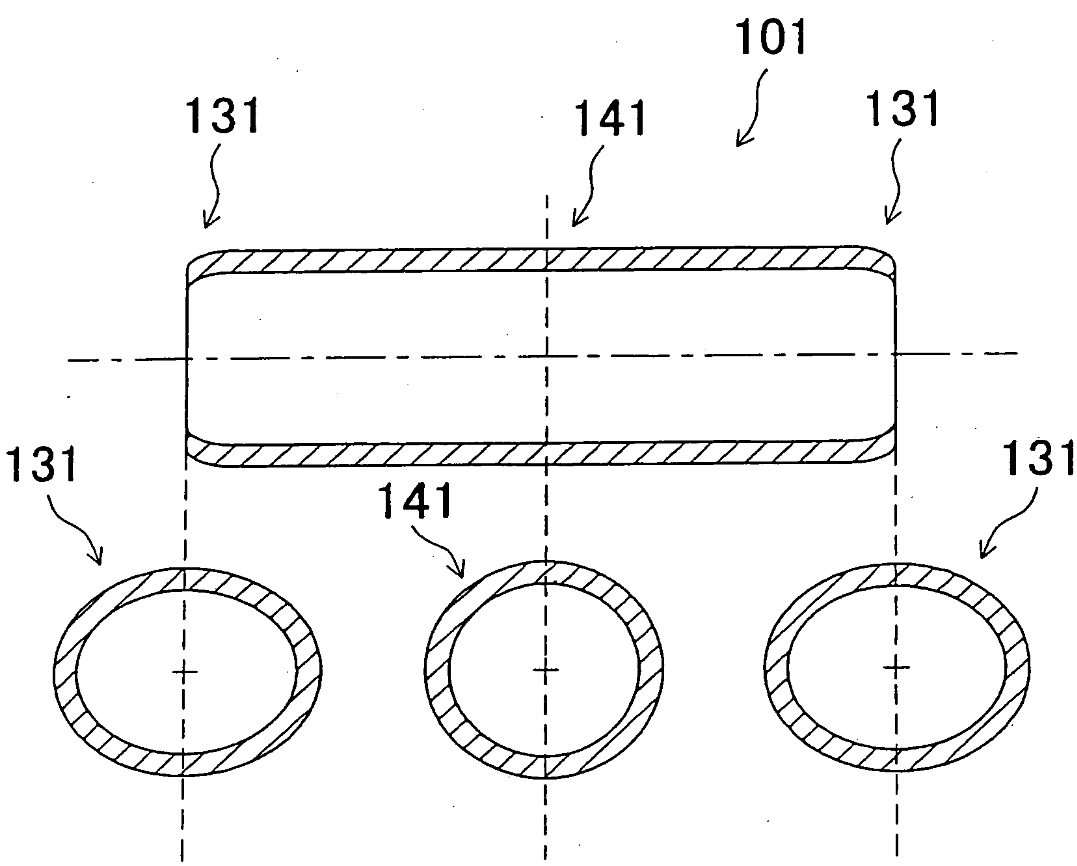
【図2】 [Fig. 2]



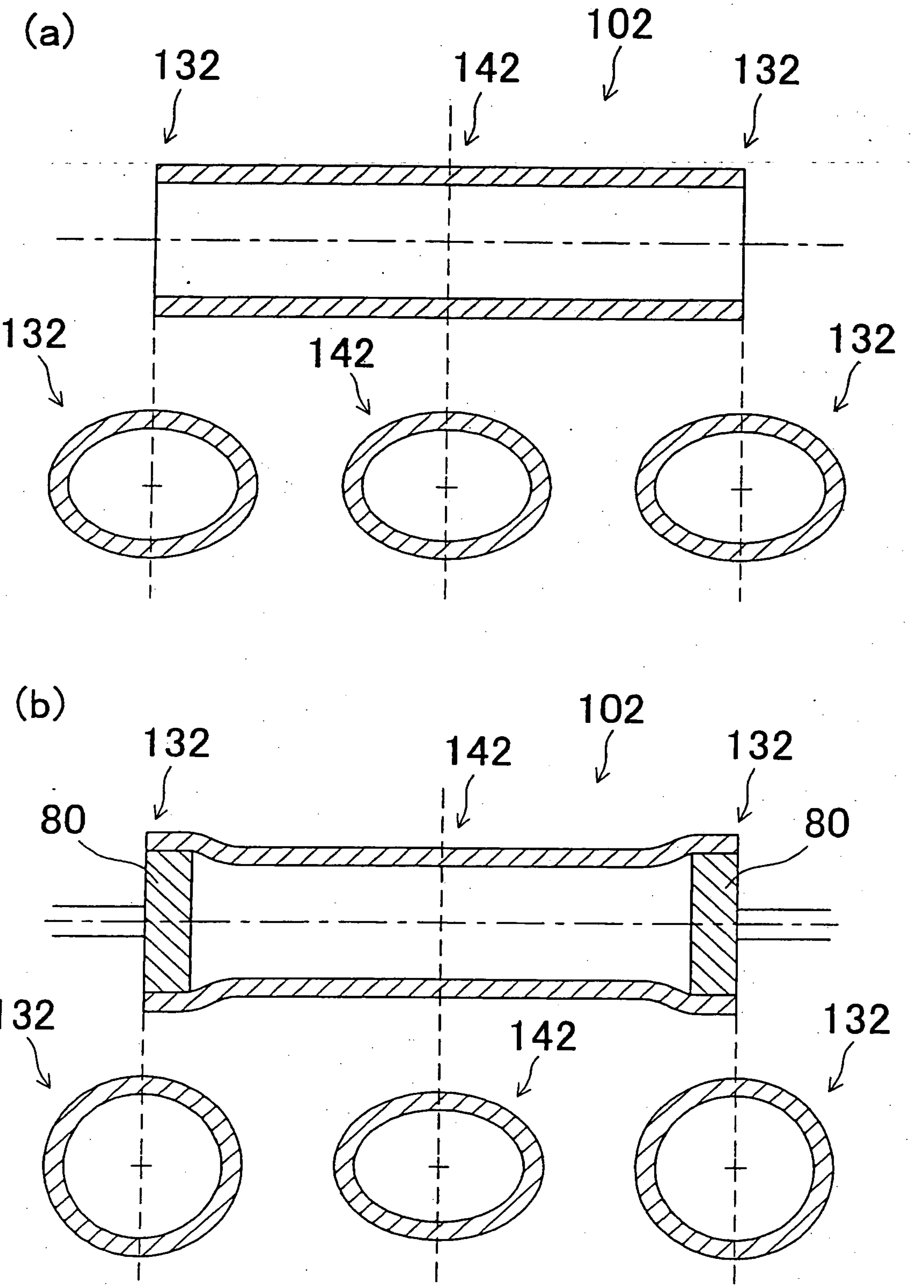
【図３】［Fig. 3］



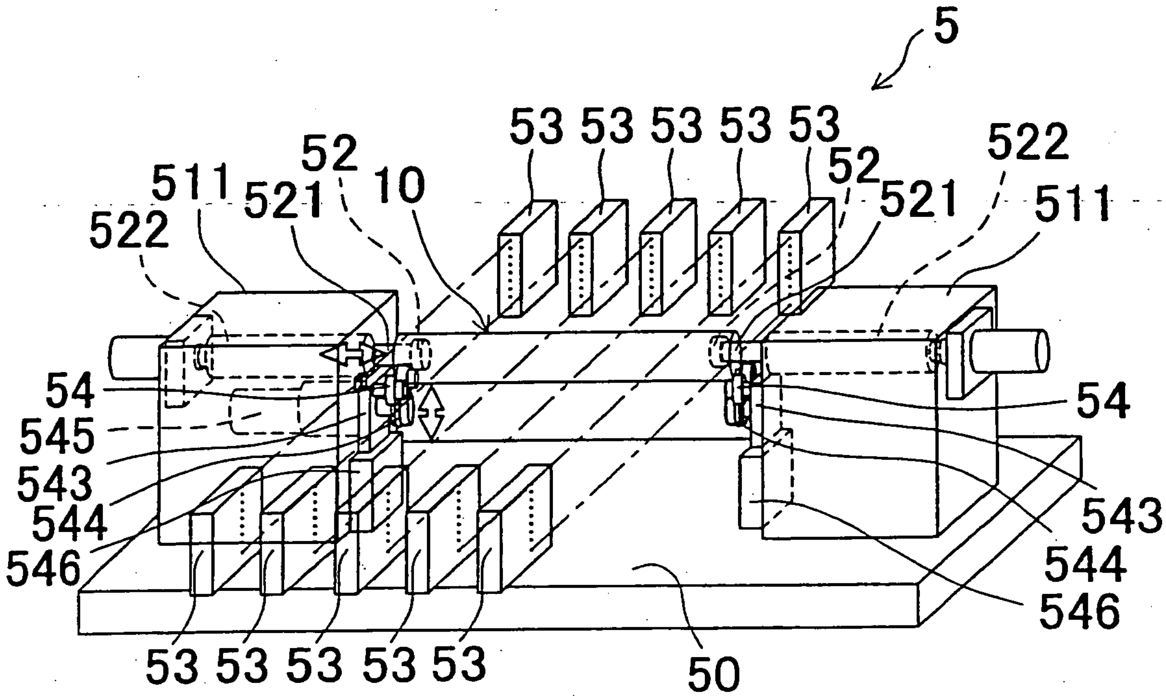
【図４】［Fig. 4］



【図5】 [Fig. 5]



【図6】［Fig. 6］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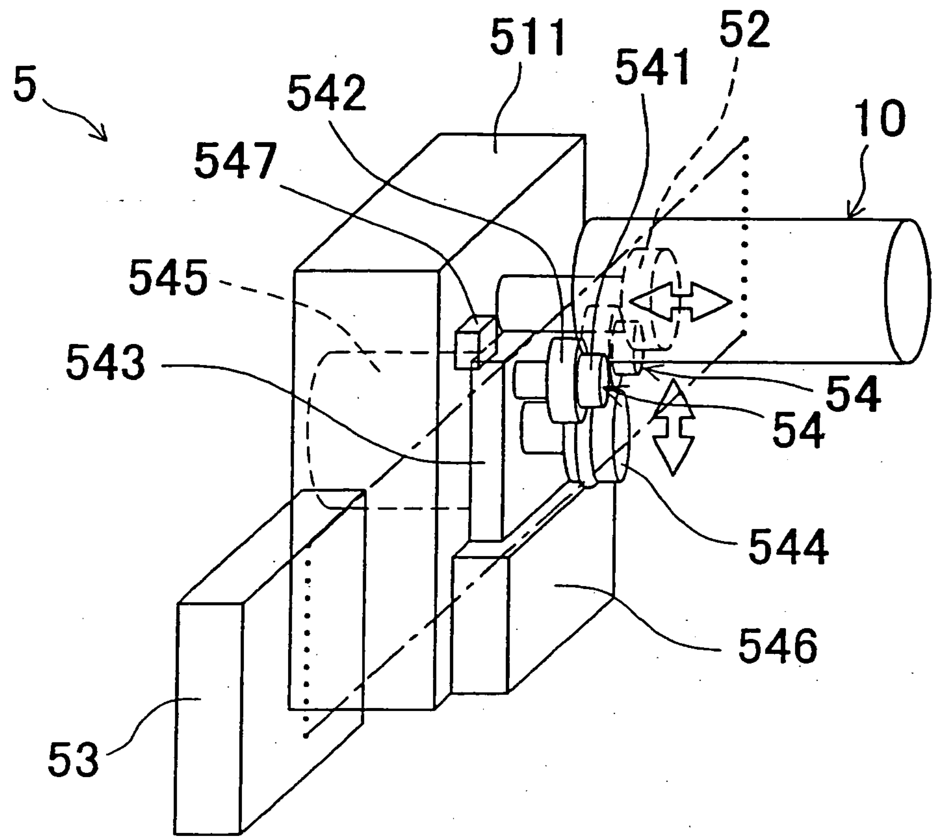
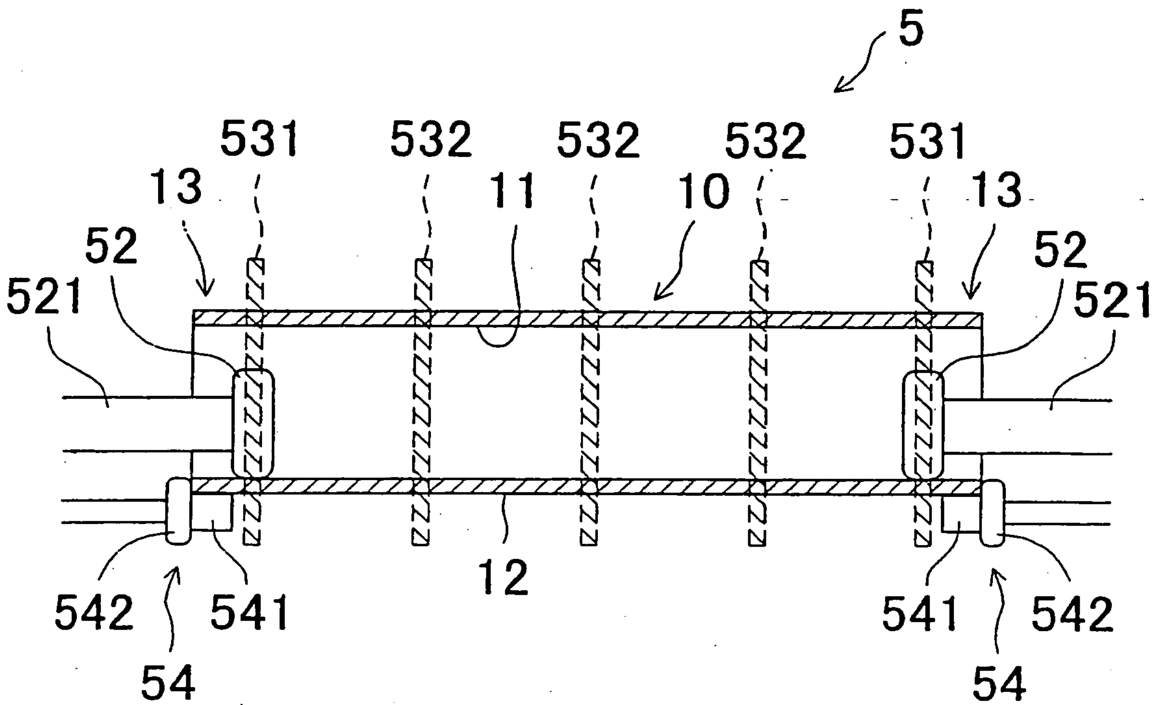
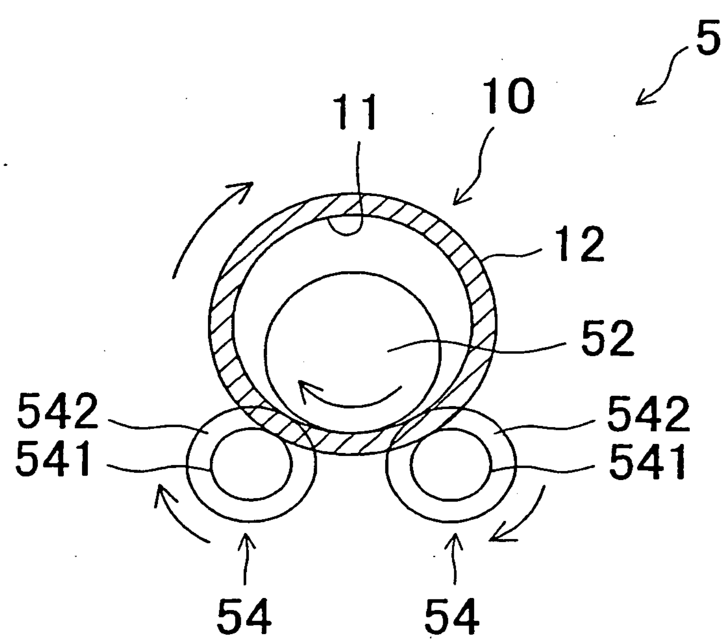
【図7】 [Fig. 7]



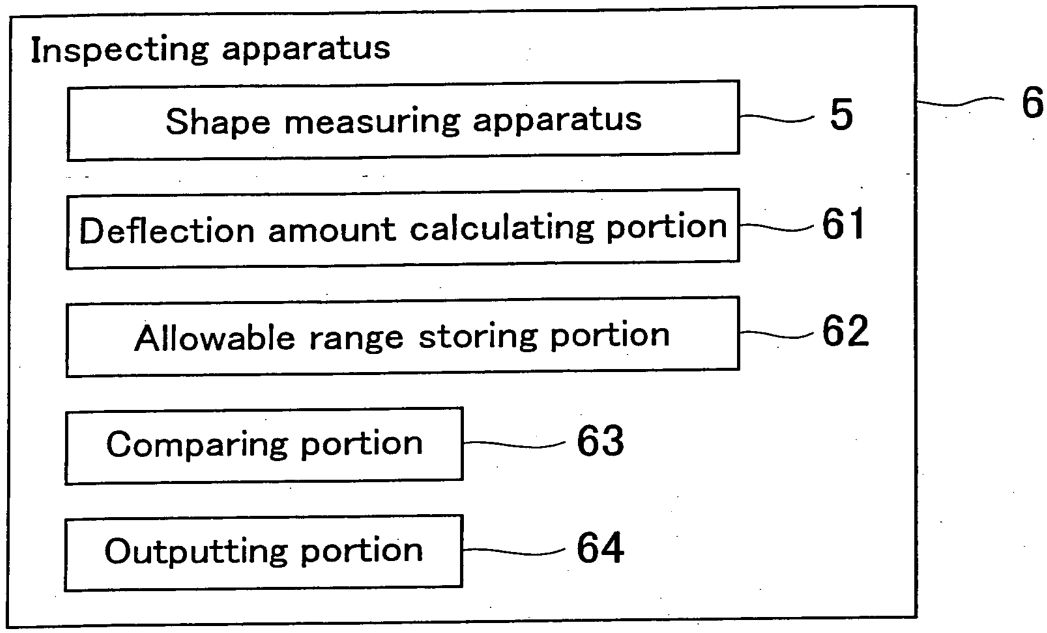
【図8】 [Fig. 8]



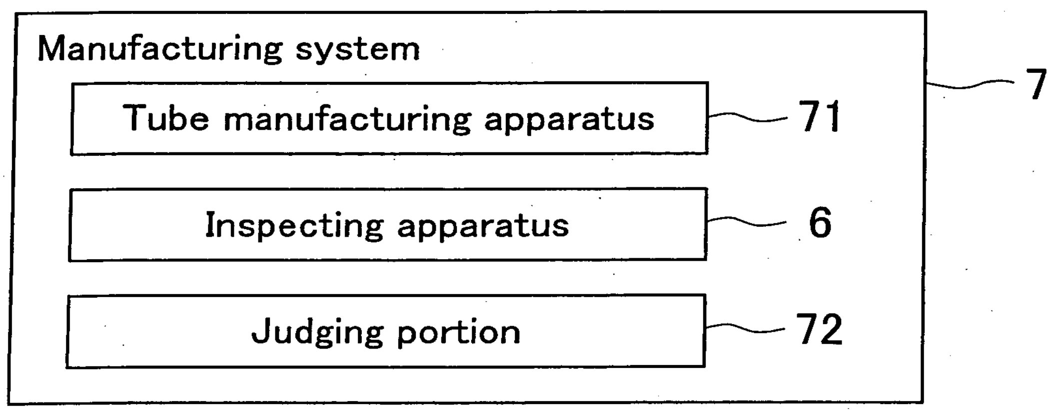
【図9】 [Fig. 9]



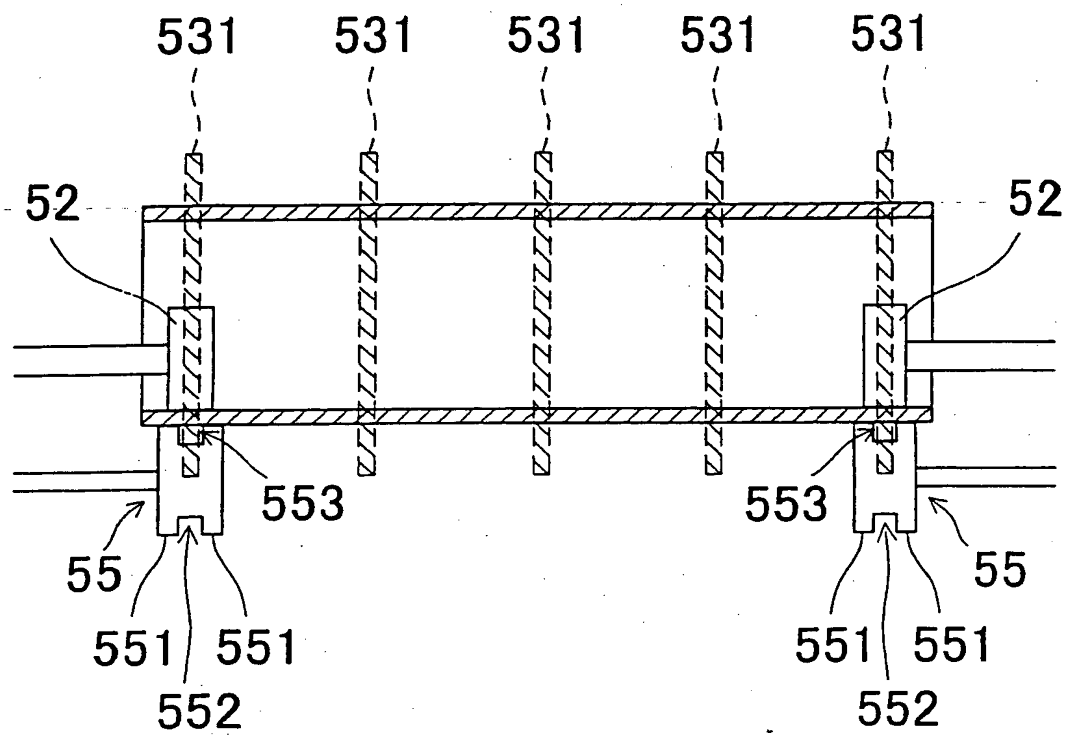
【図１０】［Fig. 10］



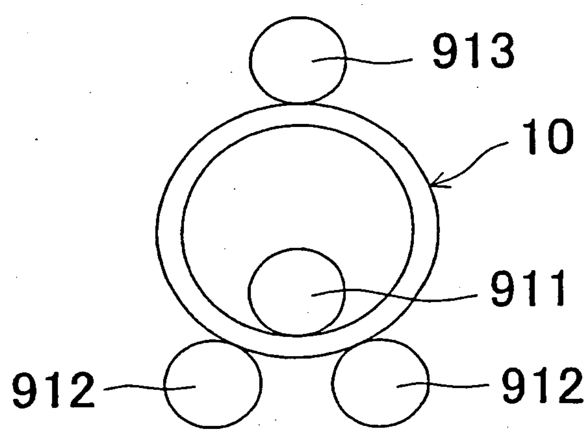
【図１１】［Fig. 11］



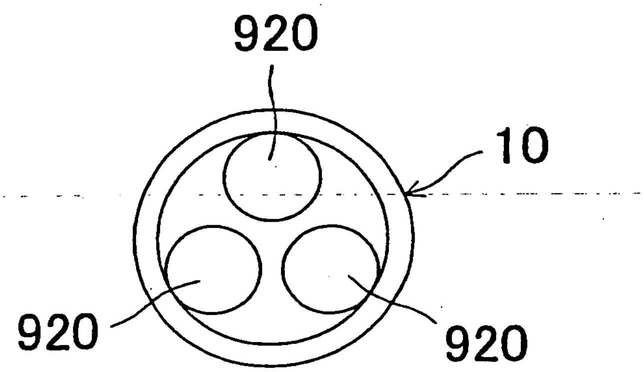
【図１２】 [Fig. 12]



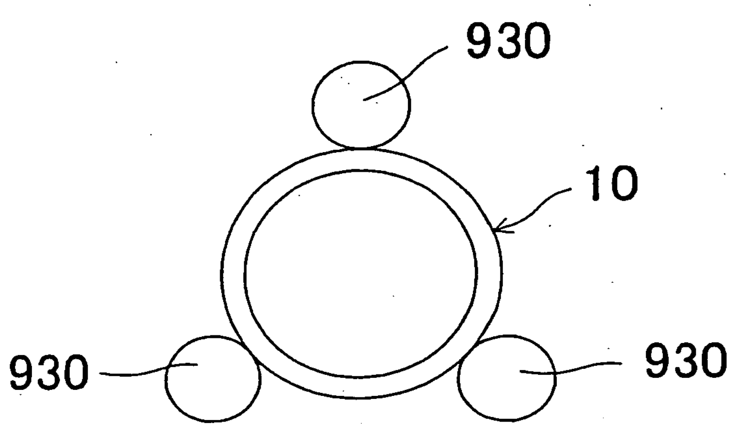
【図１３】 [Fig. 13]



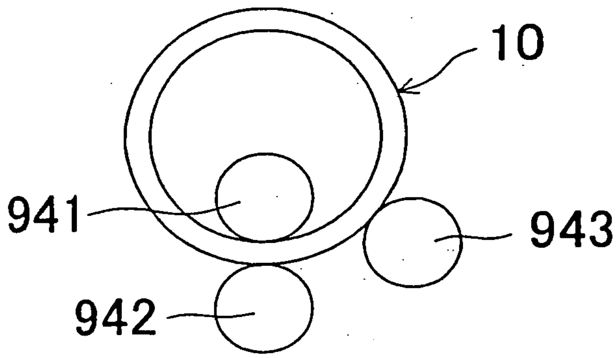
【図１４】 [Fig. 14]



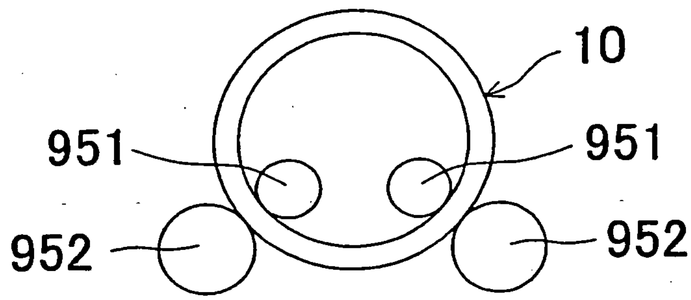
【図１５】 [Fig. 15]



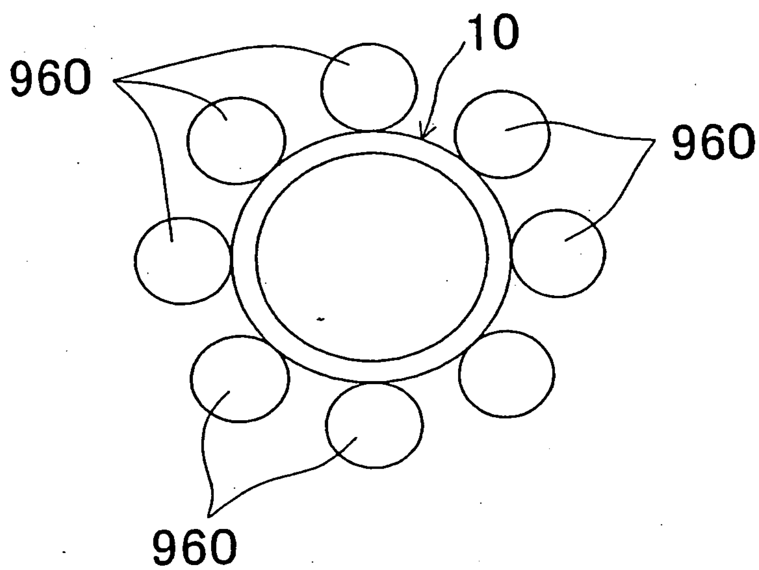
【図１６】 [Fig. 16]



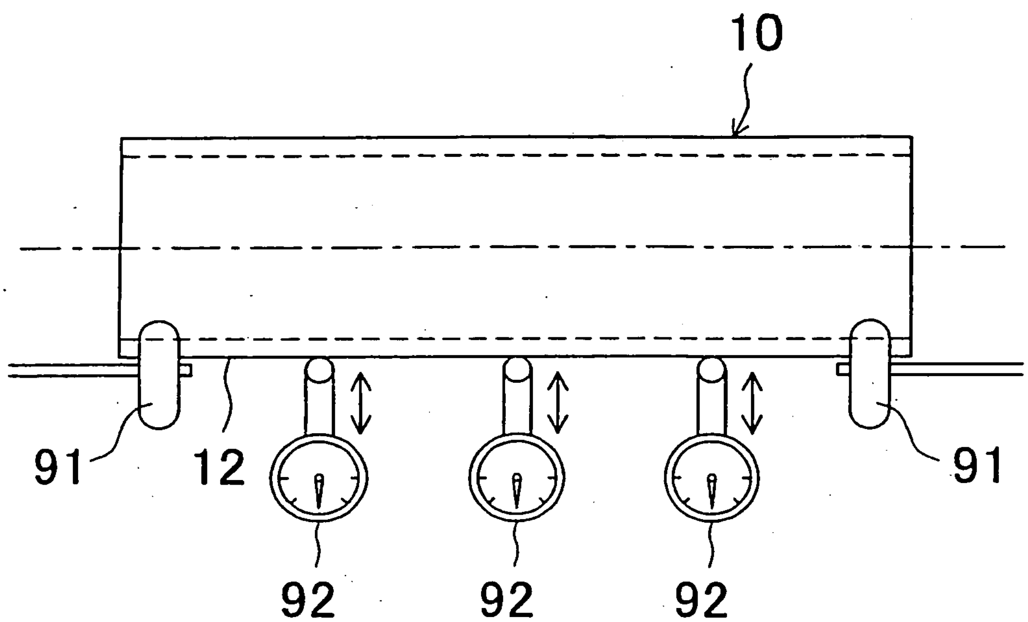
【図１７】 [Fig. 17]



【図１８】 [Fig. 18]



【図19】[Fig. 19]



【図20】[Fig. 20]